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## BIOCHEMICAL FOSSILS<sup>1</sup>

By Professor DENIS L. FOX

SCRIPPS INSTITUTION OF OCEANOGRAPHY

RECENT studies in this laboratory, to be reported in some detail elsewhere, have been concerned with preliminary qualitative and quantitative examinations of carotenoid pigments encountered in marine sediments of hundreds or thousands of years' standing. The preservation of a class of ordinarily highly labile compounds over vast ages of time is less surprising when one considers the special conditions which prevail in the buried strata of the ocean floor, i.e., lack of free oxygen, absence of light and perpetual temperatures of nearly 0° C. The added facts that carotenoids as a class are absorbed in the digestive tract of most animals only at low levels of efficiency, and that they are relatively refractory toward non-oxidative biochemical changes would still further favor their gradual accumulation in the ocean floor.

<sup>1</sup> Contributions from the Scripps Institution of Oceanography, New Series No. 232.

Pigmentary compounds of the plant and animal porphyrin series have been encountered in petroleum, coal and shale oils.<sup>2,3</sup> Similarly, other chlorophyll derivatives, accompanied by carotenoids, and sometimes also in association with fluorescent pigments common to petroleum, occur in long and deeply buried marine sediments.<sup>4,5</sup> These ancient biochromic compounds, together with other oil-soluble substances in whose presence they occur, may be regarded as diagnostic features in the search for biochemical processes in the origins of petroleum and allied natural deposits.

Carotenoids have been reported in moor soils<sup>6</sup> and

<sup>2</sup> R. Lemberg, *Ann. Rev. Biochem.*, 7: 424, 1938.

<sup>3</sup> A. Treibs, *Ann. d. Chem.*, 510: 42, 1934.

<sup>4</sup> D. L. Fox, *Proc. Nat. Acad. Sci.*, 23: 295, 1936.

<sup>5</sup> D. L. Fox and L. J. Anderson, *Proc. Nat. Acad. Sci.*, 27: 333, 1941. (N.B. The published data are in error (p. 335) by a misplaced decimal, thus appearing as 6.0, instead of the correct value of 0.6 mg per cent.)

<sup>6</sup> O. Baudisch and H. v. Euler, *Arkiv. Kemi Mineral Geol.*, 11A, No. 21, 1934.



in muds from lakes,<sup>7,8</sup> marshes<sup>7</sup> and underground caves.<sup>9</sup> Trask<sup>10</sup> has referred to carotenoids in marine sediments, but little or no emphasis has yet been directed toward the probable ages, history and biochemical significance of these pigmentary compounds in natural deposits.

In the current investigations, standard methods of carotenoid analysis were applied to samples of very fine dark mud collected from various water depths between 100 and 1,100 fathoms, both in the Gulf of California and in the open Pacific Ocean off the coast of Southern California. Oceanic muds, of estimated ages from 15 years up to 2,500 years, yielded golden, pale greenish or dirty yellow extracts, some samples containing as much as 0.20 to 0.30 mg carotenoids per 100 g of original vacuum-dried material. Gulf muds were far darker in color; one core section taken from the 16-foot level beneath the mud surface, beneath 364 fathoms of water (estimated age of the deposit being some 6,000 years) yielded about 0.6 mg of total carotenoids per 100 g of dry mud.<sup>5</sup>

An arresting fact was the consistent finding of a great preponderance of the carotene or hydrocarbon type of polyene over the xanthophyll or polyene alcohol class in mud beneath the first few inches of its surface. The finding of 80 per cent. or more of total sedimentary polyene pigments as carotenes is in striking contrast with the relative proportions of carotenoid types in other marine materials. In finely suspended marine detritus, for example, carotenes may represent from 6 per cent. to 14 per cent. of the total carotenoids.<sup>11, 12, 13</sup> Again, microscopic algae, such as *Prorocentrum micans* and *Nitzschia closterium* yield only about 10 per cent. of their total carotenoids as hydrocarbons.<sup>13, 14</sup> Species of larger marine plants such as *Fucus*, *Dictyota* and *Laminaria* contain respectively only 25.7 per cent., 15.4 per cent. and 4.8 per cent. of their carotenoids as carotenes. This list could be extended. Most marine animals which have been analyzed for carotenoids have been found to yield chiefly xanthophylls. Numerous species of fishes and ophiuroids contain xanthophyll esters as the only carotenoids.<sup>8, 15-19</sup> Species of tunicates, mollusks,

crustaceans, echinoderms and coelenterates may be added to the list of marine fauna whose tissues contain carotenoids chiefly, and in numerous instances solely of the oxygenated type.<sup>8, 13, 20, 21, 22, 23</sup>

Among the polyene hydrocarbons encountered in marine muds, the preponderant member was  $\beta$ -carotene, with compounds resembling  $\alpha$ -carotene in secondary prominence. These were often accompanied by other carotenes with properties closely resembling those of torulene from red yeasts, leprotene from certain acid-fast pathogenic bacteria, or rhodopurpurin and flavorhodin from bacteria of the *Rhodovibrio* group. Small quantities of carotenes with previously undescribed absorption spectra were occasionally found.

Chief among the polyene alcohols were xanthophylls closely resembling zeaxanthin and the spectroscopically similar diatom pigment diatoxanthin described by Strain *et al.*,<sup>23</sup> fucoxanthin and lutein (or perhaps more probably diadinoxanthin from diatoms and dinoflagellates)<sup>23</sup> and small quantities of pigments resembling taraxanthin or dinoxanthin. Prominent in hypophasic fractions also were xanthophylls spectroscopically similar to sulcatoxanthin (peridinin), petaloxanthin and antheraxanthin, while other carotenoids having a single absorption maximum similar to those of glycymerin or astacene were occasionally detected. Xanthophyllic counterparts of the bacterial carotenoids rhodopurpurin and flavorhodin, reported as occurring with the latter in *Rhodovibrio*, were not encountered in marine muds.

Concentrations of total organic matter tend to decrease with age, *i.e.*, depth of burial, of marine sediments.<sup>24</sup> Our preliminary studies indicate that lipids and carotenoids likewise so decrease, the quantities of carotenoids undergoing degradation at a rate somewhat parallel to that of total lipids.

Trask<sup>24</sup> estimates that, of the organic matter synthesized annually in a column of sea water 2,000 fathoms deep, the proportion deposited in each square meter of the ocean floor amounts to only some 2 per cent. Trask's computed loss of 98 per cent. of total organic matter is estimated by us to be accompanied by a decrease of some 83 per cent. of the original total lipids.

<sup>7</sup> B. K. Klimov and E. I. Kazakov, *C.R. Acad. Sci. U.R.S.S., N.S.*, 16: 321, 1937.

<sup>8</sup> E. Lederer, "Recherches sur les caroténoïdes des animaux inférieurs et des cryptogames." Lons-le-Saunier, Paris, 1938.

<sup>9</sup> R. A. Beatty, *Jour. Exp. Biol.*, 18: 144, 1941.

<sup>10</sup> P. D. Trask *et al.*, "Origin and Development of Source Sediments of Petroleum," p. 177. Houston, Texas. Gulf Publishing Company. 1932.

<sup>11</sup> D. L. Fox *et al.*, *Bull. Scripps Inst. of Oceanography*, 4: 1, 1936.

<sup>12</sup> Unpublished.

<sup>13</sup> B. T. Scheer, *Jour. Biol. Chem.*, 136: 275, 1940.

<sup>14</sup> N. Pace, *Jour. Biol. Chem.*, 140: 483, 1941.

<sup>15</sup> F. B. Sumner and D. L. Fox, *Jour. Exp. Zool.*, 66: 263, 1933.

<sup>16</sup> F. B. Sumner and D. L. Fox, *Proc. Nat. Acad. Sci.* 21: 330, 1935.

<sup>17</sup> F. B. Sumner and D. L. Fox, *Jour. Exp. Zool.*, 71: 101, 1935.

<sup>18</sup> D. L. Fox, *Proc. Nat. Acad. Sci.*, 22: 50, 1936.

<sup>19</sup> R. T. Young and D. L. Fox, *Biol. Bull.*, 71: 217, 1936.

<sup>20</sup> D. L. Fox and B. T. Scheer, *Biol. Bull.*, 80: 441, 1941.

<sup>21</sup> I. M. Heilbron, H. Jackson and R. N. Jones, *Biochem. Jour.*, 29: 1384, 1935.

<sup>22</sup> D. L. Fox and C. F. A. Pantin, *Phil. Trans. Roy. Soc. London, Ser. B.*, 574: 415, 1941.

<sup>23</sup> H. H. Strain, W. M. Manning and G. Hardin, *Biol. Bull.* In press.

<sup>24</sup> P. D. Trask, "Recent Marine Sediments," 440 *et seq.* Tulsa, Okla. Amer. Assoc. Petrol. Geol., 1939.



and of nearly 87 per cent. of the original carotenoids, i.e., 97 per cent. of the xanthophylls and about 33 per cent. of the carotenes.

Analyses of a core of ocean mud revealed lipids in concentrations of 0.06 per cent., 0.05 per cent. and 0.04 per cent. by dry weight at the 6-inch, 74-inch and 80-inch levels (estimated to be about 600, 7,000 and 8,000 years in respective ages). All three sections yielded chlorophyll degradation products and carotenoids; but an intermediate section taken from the 44-inch level of the same core (4,000 years) yielded similar greenish cleavage products of chlorophyll but no carotenoids. Instead it contained a pigment with blue-green fluorescence, identical in chromatographic behavior and spectral absorption maxima with a pigment recovered from a sample of California crude petroleum,<sup>5</sup> and similar to a porphyrin isolated by Treibs<sup>3</sup> from a California asphalt. This section of the core yielded tenfold the concentration of lipid-soluble substances found at the other levels.

The general preponderance of carotenes over xantho-

phylls in muds of the ocean floor may arise from several factors: (1) Xanthophylls are more readily degraded than are carotenes by atmospheric or dissolved oxygen;<sup>25</sup> this is especially true of the prominent marine xanthophyll, fucoxanthin and its isomers, which are also especially susceptible to alteration by heat or alkalis.<sup>23</sup> While the foregoing factors would find less application at the bottom of the sea, two other general processes might well contribute to the situation, both there and in overlying waters, namely: (2) The majority of marine animals so far investigated store chiefly xanthophylls rather than carotenes in their tissues; their storing and partial oxidation of polyene alcohols, with fecal rejection of carotenes could bring about a gradual preponderance of the latter class of carotenoid in bottom sediments. Finally (3) there are indications that some microorganisms living in marine muds may contribute polyene hydrocarbons of their own synthesis, and that other such flora may be capable of reducing xanthophylls to compounds of lower oxygen content, or perhaps even to carotenes.

## MODERN EVIDENCES FOR DIFFERENTIAL MOVEMENT OF CERTAIN POINTS ON THE EARTH'S SURFACE. II

By Dr. HARLAN T. STETSON

COSMIC TERRESTRIAL RESEARCH LABORATORY, NEEDHAM, MASS.

Shortly after the publication of Kawasaki's paper, Professor Schlesinger, after correspondence with me, undertook to make the necessary calculations to see if the known variation in the position of the pole that caused the annual term in the variation of latitude could not also introduce an appreciable variation in longitude for geometrical reasons. Professor Schlesinger's deductions were published in 1937 in the *Monthly Notices* of the Royal Astronomical Society,<sup>13</sup> and did indicate that a large part of the variation in longitude that we had attributed to changing positions of the moon could and should be accounted for on the basis of this annual term. Since that time I have corrected all our previously published data by applying this annual term. Though not yet published, the resultant curve still persists in showing a maximum and minimum change in longitude across the Atlantic with the hour angle of the moon. This shows up in the exchange of time signals between the Naval Observatory and both Greenwich and Paris, but not across the English Channel. The magnitude of the variation with the lunar day, however, is reduced in

amplitude by the correction to about one half the former value assigned by Mr. Loomis and myself. If the remaining variations therefore are translated into linear values there remains a variation of about 32 feet to be accounted for in the distance across the Atlantic that correlates with the position of the moon.

To add zest to the controversy a publication was shortly forthcoming from the Jesuit Observatory at Zi-ka-wei, China, showing that a study of the inter-comparison of time signals between Shanghai and the European stations at Nauan and Bordeaux, revealed periodic variations in longitude between Berlin and Zi-ka-wei, dependent upon the moon's position. The explanation advanced was an earth tide causing a linear variation in distance of 60 feet between central Europe and the east coast of China. The amount of the variation given was several times larger than any probable error of the observations.

Unfortunately after June, 1934, shortly after the publication of our original papers, the daily inter-comparisons of the 17.6 Kc. transatlantic time signals between our own Naval Observatory and the observa-

<sup>13</sup> F. Schlesinger, "Note on Annual Change in Longitude." *MNRS* 97: 696, 1937, 98: 203, 1938.

<sup>25</sup> L. Zechmeister, "Carotinoide," J. Springer, Berlin, 1934.



tory at Greenwich ceased, due to change in the transmitting station at Annapolis. We were obliged, therefore, to try to continue this study through time signals on short wave length, or high frequencies. The short wave transmission, however, across the Atlantic is so unreliable, particularly during the summer, that the project had to be abandoned until the 17.6 kilocycle frequency could be re-established. Through the co-operation of the American Geophysical Union and Captain Hellweg, superintendent of the Naval Observatory, the time signals were resumed on the 17.6 kilocycle frequency in 1939. However, hardly had the interchange of time signals on this reliable wave-length been re-established before the European War broke and we have since been deprived again of this source of data.

Meanwhile an exhaustive study was begun at the Naval Observatory to see if any lunar effect in time observations could be detected from observations made at Washington with the photographic Zenith tube. The result of this series of investigations seemed to show that observations from March, 1934, to February, 1939, showed a small correlation with the moon of only such magnitude as to be consistent with an earth tide calculable on the basis of the accepted constants for the earth's rigidity. If apparent variations in longitude from time comparisons on two sides of the Atlantic were due to earth tide deformation, one would expect that results at either of the two observatories concerned would show a certain dependence of meridian observations upon the hour angle of the moon. However, it should be stated that between the date of publication of the paper by Mr. Loomis and myself and the date at which the observations at the Naval Observatory were studied, our intercomparison of the time signals showed a decadence in the amplitude of the lunar effect.

Since the complete abandonment of the 17.6 kilocycle transmission, no further study could be made. Meanwhile other computers at the Naval Observatory have investigated latitude observations made at Washington, and have found no variations with the moon other than what could be accounted for on the accepted theoretical earth-tide basis. I venture, however, to continue to stress that in any rigid harmonic analysis of a long series of observations, only those terms will persist which show a uniform rhythmic oscillation throughout the whole period of time in which the data were collected. Such a method of analysis does not allow for the possibility of an intermittent lagging effect such as might occur were deformation irregularly resisted, as might well occur in creep phenomena. The last chapter in the discussion of this problem does not yet appear to have been written.

In arriving at our earlier published conclusions, Mr. Loomis and I pointed out that in interpreting the variation in time signals exchanged across the Atlantic we had tacitly to assume that the speed of the radio waves carrying the signal was the same in passing from west to east as in passing in the opposite direction; and that the velocity of the wave does not substantially change during the interval covering each day's exchange of signals, an assumption which should be reasonable, but which can not indefinitely pass unchallenged. Experiments for the verification of such an assumption have already been planned,<sup>14</sup> and should be carried out after the termination of the war.

May I now call your attention to such evidence as exists for two of the most astonishingly large changes in geographical coordinates that have ever been published from the study of the intercomparison of astronomical determinations. One of these concerns Greenland; the other, South America.

In 1932 a Norwegian, Hans Jelstrup,<sup>15</sup> conducted an expedition in the summer of that year to Sabine Island, in the Melville Bay region, off the west coast of Greenland. The purpose of his expedition was to re-occupy a station whose latitude and longitude had been determined by Børgen and Copeland in 1867 and 1870. Jelstrup identified the identical pier used by the observers in 1870. The results of the new determination gave the position of this pier as 615 meters west of the position given by Børgen and Copeland in the 1870 observations. The comparison of the longitude determined by Jelstrup with that given by Børgen and Copeland in 1870 has been questioned on the grounds of inaccuracy of the earlier observations; and Jelstrup's conclusion that in 1932 the station was 615 meters west of the earlier position has been warmly challenged.

It is true that Børgen and Copeland did not have the advantage of the modern radio for time comparison, and did not even have the use of a cable for receiving Greenwich time. They were therefore obliged to depend upon lunar culminations and observations of occultations for determining Greenwich time. These methods are well recognized as quite unsatisfactory and lacking in precision compared with the telegraphic or radio method. It is of interest, however, to find just what degree of reliability could be placed upon those early determinations. For this reason I have taken the trouble to examine with considerable care the original detailed publications of the 1870 expedition.<sup>16</sup> Their probable error was about plus or minus

<sup>14</sup> H. T. Stetson, *Trans. of Amer. Geophys. Union*, 1940, p. 822.

<sup>15</sup> H. S. Jelstrup, "Détermination Astronomique A Sabine-Øya Au Groenland Oriental. Skrifter Om Svalbard Og Ishavet." Nr. 58, 1933.

<sup>16</sup> K. Koldewey, "Die Zweite Deutsche Nordpolarfahrt in den Jahren 1869-1870," Leipzig, 1874, Vol. 2: 710-724.

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1.1 seconds for either method. The longitude determinations from the four-star occultations agree within 1.5 seconds of the longitude found from the sixteen lunar transits; as good an agreement as could be expected in the case of the methods used. Observations were also made by Green in 1870 to determine the corrections to the moon's position, thus minimizing uncertainty due to this possible source of error.

The uncertainty of Børgen and Copeland's observations of longitude expressed linearly amounts to about 80 meters, while the modern observations of Jelstrup in 1932 could represent an uncertainty of not more than 20 meters. Now if we allow for the worst possible combination of these estimated errors it would appear that the results in 1932 could be expected to agree with the 1870 observations within about 100 or at least 200 meters, whereas the position actually found by Jelstrup was indicated to be 615 meters west of the position determined from the earlier measurements. Consequently, it would appear that in the 62 years interval Sabine Island had moved west four or five hundred meters.

Critics of this interpretation should bear in mind that there is also evidence of movement from the comparison of the latitude determinations made in 1870, with those made in 1932. Jelstrup's value for the latitude was  $3''.2$  less than that found by Børgen and Copeland in 1870, an amount which indicates that the pier as was occupied had moved 100 meters south of the 1870 position. Whatever doubt may be cast upon the interpretation of the longitude differences it should be emphasized that the latitude determinations were entirely independent of the exchange of time signals, and that the order of accuracy attained for latitude determinations in 1870 was probably nearly as good as in 1932. The uncertainty involved would appear to rest chiefly upon the question of the positions of the stars used. The conclusion of the Børgen-Copeland and Jelstrup expeditions would seem to indicate that Sabine Island had drifted south and west at least some seven hundred to eight hundred feet during the 60 years elapsed between the expeditions.

Now for the other startling incident. In 1931 a redetermination of the longitude between the Argentine observatory at Cordoba and the Royal Observatory at Greenwich was made and the results compared with the position of the observatory made under the direction of Dr. Benjamin A. Gould in 1871.<sup>17</sup> Every astronomer recognized Benjamin Gould as one of the most exacting and painstaking of observers and mathematicians. It would appear that he would have used every precaution to secure the highest attainable degree of precision possible in his time. Dr. Gould based his position upon two very careful longitude deter-

minations carried out by the U. S. Naval Astronomical Expeditions. These expeditions derived independently the longitude of Buenos Aires from Greenwich and that of Valparaiso from Washington. One of these determinations was made by way of the Atlantic and one by way of the Pacific. The results of the two determinations showed a satisfactory agreement within 0.05 seconds or a linear uncertainty of some 16 meters.

In the determination of 1931 time signals were exchanged by radio in place of cable and the probable error from 35 nights' observations gave an uncertainty of the resulting longitude represented by a probable error of but  $\pm 0.007$  seconds. When, however, the 1931 result was compared with that of 1871 the two determinations differed by 1.11 seconds corresponding to a linear distance of 400 meters or 1,200 feet, an unthinkable difference to be charged to the account of observational errors.

Discussing the results, Astronomer Zimmer, of the Cordoba Observatory, tacitly assuming that the observatory could not have moved, commented on these results as follows: "The remarkable thing about it is that two independent determinations such as those made by Green and Davis, should be in complete accord, and yet be wrong by a whole second. We have to assume that those two determinations were in error by at least a round second." Mr. Zimmer found it impossible to imagine any continental drift to allow for the change that had taken place, especially so since he stated that if one were to imagine any such movement, "the direction was opposite to that predicted by Wegener." One perhaps should be cautious in evaluating such a statement lest it lead to a type of reasoning that may discourage discovery, by inhibiting the imagination on the one hand, and erroneously assuming on the other hand that if a lateral movement had taken place it would have to be in accord with some particular hypothesis. Perhaps it is a pernicious imagination that would suggest that if an orogenic movement had at one time been westward, there might be a reactionary period when a crustal shift could for the time being take place in the opposite direction. This is something for you geologists to ponder about.

In closing this discussion of longitude variations there remains one other observation to mention—the results of a comparison of longitude determinations between San Diego and Washington, made during the campaigns of 1926 and 1933, and published in 1939.<sup>18</sup> A comparison of the observations of longitude reduction over this seven-year interval taken at face value, showed that the longitude determination in 1933 was 0.045 seconds greater in 1933 than in 1926, an amount over six times the probable error of the observations.

<sup>18</sup> C. B. Watts, P. Sollenberger and J. E. Willis, *Pub. U. S. Naval Observatory*, Second series 14: 254, 1938.

<sup>17</sup> M. L. Zimmer, *Astr. Jour.*, 41: 115, 1931.



This amount expressed in linear dimensions would correspond to an increase in the distance between the east and west coast of 55 feet. This discrepancy seemed so much larger than errors in the observations could allow that the Naval Observatory astronomers re-examined the reductions of the 1926 observations and came to the conclusion that a small correction to the reading of the chronograph records by the earlier computers could be made so as to bring the results of the two series more nearly in accord. Even after such corrections were applied, it is found that in 1933 San Diego appears 37 feet further west than the 1926 observations indicated.

One should emphasize here that there has been a vast improvement in the technique of determining longitude in the last fifty years, largely through the advent of frequent time comparisons by radio. In place of being dependent upon cable lines one can receive at will in any field station, time signals broadcast with an accuracy undreamed of a century ago. Nevertheless with every advance in obtaining another decimal place, one is sure to encounter new problems to be solved. In this case we have no exception to the rule. In recent studies we have made on the apparent elapsed time in the propagation of radio signals between distant points, it has been found that it is no longer safe to assume that the velocity of these radio waves are constant and equal to that of the velocity of light, an assumption all too easily made by those who have not faced directly some of the problems of communication by way of the ionosphere.

In a paper published in the *Journal of Terrestrial Magnetism* in 1936<sup>19</sup> I showed that, in deriving the velocity of propagation of time signals employed in the longitude campaign of 1926, the apparent group velocity of the radio waves deduced on the assumption that the waves traveled the shortest possible path between stations, varied in speed all the way from values approximating the velocity of light, to values approximating but a little more than two thirds the velocity of light. Furthermore, there was indication that the speed appeared to depend more or less directly upon the intensity of the earth's magnetic field in the region over which the waves passed.

Even in the case of constant comparisons between two fixed stations such as Greenwich and Washington, it was found that over a period of six years the velocity of the radio time signals could vary appreciably, for reasons not readily explained. The inference of this would seem to be that in attempting to obtain a still higher degree of accuracy in determining longitude we are involved in a study of ionospheric conditions, upon which the peculiarities of radio

transmission must depend. For a higher degree of precision in longitude determinations, it would appear desirable that the observing stations involved should be in relatively close proximity to wireless stations which transmit the signals.

#### VERTICAL DISPLACEMENTS

We may now dismiss completely the matter of astronomical determinations and call your attention for a moment to the possibility of measuring short periodical displacements of the earth's crust in the vertical direction. Thanks to the improvement in gravimetric instruments within the last few years, it has been possible to measure variations in gravity with a degree of precision never before attained. While the modern gravimeter has been developed ostensibly for commercial purposes, one of these instruments placed for several months in a fixed location has revealed so unmistakably the rise and fall of the earth's crust in response to solar and lunar tides in the earth itself as to render the results unquestionable.

A few years ago I took the opportunity of visiting the Gulf Research Laboratory in Pittsburgh, where, under the direction of Drs. Foote and Eckhardt, a sensitive gravimeter set up on test in the basement of the laboratory for several months had shown consistently both the solar and lunar tides in the solid earth. The tidal curve reduced from the gravimeter observations, when compared with the calculated theoretical tide potentials, showed a definite phase lag of about 50 minutes between the time of the maximum tidal force and the time of the maximum response of the earth's crust.<sup>20</sup> While the experts in charge of this instrument felt that caution should be exercised in determining the amplitude of the curve on account of certain uncertainties in the calibration of the instrument, one could state with certain reservations that the range of movement of the earth's crust in the vertical direction during the lunar day represented a displacement of about two feet. Were there only this single incident, it is quite sufficient to emphasize the importance of the establishment of a number of such gravimeters in selected regions to determine not only such differential displacements, but to discover if possible regions where such displacements may exceed or fall short of the magnitude of the variations recorded at Pittsburgh.

As a possible cosmic cause for differential movements in the earth's crust, one can not forget the gravitational force exerted by the moon. It is always difficult to see how the very feeble stresses set up in the earth's crust by the lunar tidal attraction could have an appreciable effect in moving large continental masses. One perhaps should not, however, forget the

<sup>19</sup> H. T. Stetson, *Terr. Magn. and Atmos. Elec.*, 41: 287, 1936.

<sup>20</sup> P. D. Foote, *SCIENCE*, 82: Supp. P8, 1935.



possible resultant effect through the continued application of intermittent stresses repeatedly applied in given direction. Were it possible to think of extended regions of mobile matter within the earth, then perhaps tides set up in this underlying mobile material could produce, through hydrostatic pressure, far-reaching effects in this connection.

A few years ago I undertook a reinvestigation of the frequencies of the occurrence of major seismic disturbances as possibly correlatable with the position of the moon.<sup>21</sup> While the results were not as conspicuously convincing as one might have wished, there was a definite indication that, at least so far as deep focus earthquakes are concerned, the curve of frequency deduced showed two maxima and two minima during the lunar day. Maximum values coincided with positions of the moon four hours and sixteen hours past the meridian. One might say that there are indications here of a trigger action, such that if through accumulated stresses large earthquakes are about to occur, there is a better chance of their occur-

rence during a time when the horizontal tidal component of the moon's gravitational force is at a maximum.

A few days ago I received a communication from that venerable and esteemed geologist, Professor William Hobbs of Michigan. Said Professor Hobbs to me, "If you have published material proof of the changes of latitude and longitude, could you send reprints, or else references to place of publication." By training and temperament I think any scientist is reluctant to use the word proof, and while the material I have presented may have fallen far short of what any mathematician could desire as proof, I hope I have fairly and without undue prejudice presented such evidences as exist to encourage a degree of open-mindedness among both astronomers and geologists on so fundamental a question as that of differential movements in the earth's crust now going on. If so, then I will have been successful at least to the extent of having presented material consistent with the subject assigned.

## OBITUARY

### RONALD FRASER MACLENNAN

In these days, when full millions of men of pre-middle age must necessarily turn their potential physical and intellectual energies into the kinetic form necessary to winning the war, the death of a single member of that age-group may pass almost unnoticed. However, when such an individual was already a teacher and trainer of, and inspiration to, hundreds of students at the upper educational level, the loss reaches into a long and incalculable future.

For this reason the passing of Ronald Fraser MacLennan on May 27, 1944, of coronary thrombosis, at thirty-seven years of age, has more than commonplace significance. He took his A.B. at Oberlin College, in the town of his birth, in 1928, with honors in zoology; an A.M. in 1930 and the Ph.D. in 1932, both at the University of California (Berkeley). He was at once appointed instructor on the zoological staff of the State College of Washington, there advancing to the associate professor level; in 1940 he was called back to his alma mater. While his teaching was an outstanding activity and success, always carrying a heavy schedule, he was never lacking in eagerness for research; eighteen carefully wrought studies in the field of protozoology appeared during the twelve years following attainment of the doctorate. He was also one of "the biologists who, in our opinion, were the best men,—who could speak with authority, to write these chapters" (quoted from preface); Mac-

Lennan was thus chosen to present "Cytoplasmic Inclusions" in the large treatise on "Protozoa in Biological Research" (1941) edited by Calkins and Summers.

Oberlin has a new biological laboratory in the offing, and the confidence placed in his judgment is indicated by the action of the administration in releasing him from other duties for a half year while he cooperated with the architects. Further portrayal of the role he was filling can best be given in summary by quoting from the memorial minute adopted by the faculty on June 6:

All of us had every reason to assume that his would be a long and brilliant career. Of this there was abundant promise. It showed itself in his already numerous and significant scientific publications, in the enthusiastic and affectionate relationships established alike with colleagues and with students, and in many active services for his church and for the village.

To those of us who were closest to him in his daily work, his ready and engaging smile, his unfailing wit and good humor, his quick assumption of his full share and more of any task however arduous, and his careful, critical, yet unassuming scholarship were a constant inspiration.

He is survived by his wife, Mrs. Marie Schulte MacLennan, and a son, Frederick; by his mother and two sisters. Memberships in scientific organizations included the American Association for the Advancement of Science, American Microscopical Society, American Society of Zoologists and the corporation of the Marine Biological Laboratory.

ROBERT A. BUDINGTON

<sup>21</sup> H. T. Stetson, *Proceedings Am. Philosophical Society*, 8: 411, 1937.



## RECENT DEATHS

SELSKAR MICHAEL GUNN, vice-president since 1927 of the Rockefeller Foundation and from 1922 to 1927 director of the Paris office of its International Health Board, died on August 2 at the age of sixty-one years.

EDWARD BAUSCH, chairman of the board of the Bausch and Lomb Optical Company, Rochester, N. Y., died on July 30. He was eighty-nine years old.

A CORRESPONDENT writes: "Professor Charles Homer Baxter, head of the departments of civil and mining engineering at the Michigan College of Mining and Technology, died on July 29 after a brief illness. Professor Baxter had been head of the departments since

1927. He was a graduate of the college in the class of 1902. For many years he engaged in mining, and was superintendent of large iron-mining operations. He was the senior author of a standard work on mining examination and valuation, had served on various trade bodies and was an expert witness in the Minnesota Taxation Cases of 1935. He had also been president of the National Alumni Association of the Michigan College of Mining and of the Lake Superior Mining Institute."

DR. RAMÓN G. LOYARTE, director of the Institute of Physics of the National University of La Plata, Argentina, died on May 30.

## SCIENTIFIC EVENTS

## THE KRESGE-HOOKER SCIENTIFIC LIBRARY

THE original collection of books now known as the Kresge-Hooker Library was made by Samuel Cox Hooker, whose complete biography has been written by C. A. Browne.<sup>1</sup> Dr. Hooker was a native of England who received his Ph.D. degree from the University of Munich and then came to America with the hope of securing a position at a university. Being disappointed in his efforts, he accepted a position with the Franklin Sugar Refining Company and became a sugar chemist in 1885. After thirty years of outstanding scientific, technical and financial success in that field, he retired at the age of 51 to devote the remainder of his life to private research and the assembling of a world-famous library. During the next 20 years he had representatives in various foreign countries to help him complete his collection.

At Dr. Hooker's death in 1935, the library was catalogued and offered for sale. At the spring meeting of the American Chemical Society Dr. Charles L. Parsons announced that the library was for sale. Since the writer was to take a position at Central College the following fall he felt that this offer might present an opportunity to acquire certain additions for its library.

Mr. Sidney W. Davidson, of New York City, was the executor for the estate, and on reaching his office it was learned that the Hooker Library would not be divided. Mr. Davidson stated that he had already had offers of \$100,000 for the entire library from three different industries, but he had not accepted any of them because it had been Dr. Hooker's request that it go to some college or university, if possible, preferably in the West. The writer was able to get a 24-hour option on the library for Central College. In order that Dr. Hooker's request might be fulfilled, the

<sup>1</sup> *Jour. Am. Chem. Soc.*, 550: 1936.

heirs of the Hooker estate contributed \$30,000, while Mr. G. A. Pfeiffer and Mr. and Mrs. Henry Pfeiffer of the William R. Warner and Company, Inc., contributed the other \$70,000 for the purchase of the library. The Chemical Foundation paid for moving the library from New York to Central College.

Central College accepted the gift without taking time to ascertain the cost of maintaining such a library. When this cost was ascertained, it proved to be greater than the college could bear. Thereupon the writer organized the society known as the "Friends of the Hooker Scientific Library" in order, first, to create an endowment fund for keeping the library up to date, and, secondly, to form an organization through which the library might have a greater function than serving a small college. In the fall of 1941 Dr. Julian F. Smith, of the du Pont Company, was employed to help make the library more serviceable by providing translations, abstract work, searches, photo copies, etc. This organization continued until the spring of 1942, when the writer accepted the chairmanship of the Department of Chemistry at Wayne University, Detroit, Michigan, under the condition that he be permitted to attempt to transfer the Hooker Scientific Library to Wayne University.

On examination of the problem of the transfer by a committee of Detroit chemists, it was found that, in order to make the transfer on a satisfactory basis, \$200,000 would be required. The first \$100,000 would be for the purchase of the library, and the second for providing publications for which subscriptions had lapsed so that the library might once more claim the title of being the most complete one in its field in the world. Furthermore, the plan called for the maintenance of the library by Wayne University. This general plan was specifically presented to some industries outside Detroit, as well as in Detroit, with the result that five donations were quickly obtained from



the following companies: The William R. Warner and Company, Inc., the Hercules Powder Company, outside of Detroit, and the General Motors Corporation, the Ethyl Corporation and the Miner Estate, inside of Detroit. These gifts were for \$5,000 each, subject to the condition that the total amount of \$200,000 be raised. During the summer of 1943 Central College had two other offers of \$100,000 each for the library, and, therefore, since there was only an oral option on the library until January 1, 1944, it was agreed with the college that the option would terminate on October 20, 1943.

Since \$200,000 had to be raised, it was evident that larger donations than \$5,000 were necessary. On October 2 the writer called on the Kresge Foundation and presented the problem to Mr. Stanley S. Kresge, who promised to take it up with his Board in a few days. The result was that on October 19, the Board authorized the gift of \$100,000 to purchase the Hooker Scientific Library, thus making it possible to exercise the option on October 20.

In addition to the gift of \$100,000 by the Kresge Foundation, the following companies gave \$5,000 or more for the project, and many individuals and other companies made smaller contributions: Chrysler Corporation, Dow Chemical Company, Ethyl Corporation, Gelatin Products Company, General Motors Corporation, Hercules Powder Company, Miner Estate, Parke, Davis and Company, W. R. Warner and Company, Inc., Wyandotte Chemicals Corporation.

NEIL E. GORDON

WAYNE UNIVERSITY

### THE NATIONAL ELECTRONICS CONFERENCE

A PROGRAM covering television, ultra-high frequency and radio developments in the communications field, and industrial measurements, electronic controls, induction heating, and power and medical applications of electronics is being arranged for the National Electronics Conference which will be held at the Medinah Club, Chicago, on October 5, 6 and 7.

The conference is sponsored by the Illinois Institute of Technology and Northwestern University as participating sponsors, and the Chicago Section of the American Institute of Electrical Engineers and the Chicago Section of the Institute of Radio Engineers as cooperating sponsors.

Dr. J. E. Hobson, director of the School of Engineering of the Illinois Institute of Technology, who is chairman of the executive committee, states that the first conference is planned to provide: (1) a technical meeting for the presentation of original papers covering fundamental developments in electronics and the applications of electronic apparatus; (2) a forum for the review and correlation of recent electronic

developments in their proper perspective; (3) a symposium for the interchange of ideas, methods of approach and technique between scientists and electronic engineers working in different fields of application, and (4) an educational conference to acquaint engineers with this relatively new and rapidly expanding field. He points out that in addition to providing a permanent record of technical and application papers for reference and study the conference should help to integrate and correlate work being done in fields rather divergent in their applications of electronic devices and principles.

Although including the use of electronics in communications, the first conference will emphasize scientific developments and also applications in industry, processing operations, power conversion, measurements, medicine and in similar fields. Opportunity will be given for discussion. A program, embracing all important fields of electronics, has been prepared by Professor Arthur B. Bronwell, Northwestern University, who is also chairman of the Program Committee. The opening address, entitled "Electronic Research Opens New Frontiers," will be given by Ralph R. Beal, research director for the Radio Corporation of America.

The Medinah Club, 505 North Michigan Avenue, will be headquarters for the conference. It will have facilities for all activities and can accommodate approximately two hundred and fifty of those who may wish to stay there. The club will reserve rooms in the nearby North Side hotels to provide for any overflow. Those planning to attend are urged to make their hotel and train reservations at an early date.

The Arrangements Committee, of which Professor P. G. Andres, of the Illinois Institute of Technology, is chairman, will accept registrations for the conference by September 1. Advance registration by mail is desirable.

Further information may be obtained from Dr. Hobson, who can be addressed at the Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Ill.

### A HARVEY W. WILEY MEMORIAL SYMPOSIUM

At the one hundred and eighth meeting of the American Chemical Society to be held from September 11 to 15 in New York City under the presidency of Thomas Midgley, there will be presented a symposium sponsored by the Division of Agricultural and Food Chemistry, which will commemorate the one hundredth anniversary of the birth of Harvey W. Wiley, "Father of American Food Chemistry," who was born on October 18, 1844. Dr. N. B. Guarrant, of Pennsylvania State College, chairman of the division, will preside.

Food quality, to attain which Wiley finally secured



in 1906 the passage by Congress of the Food and Drugs Act, will be emphasized in the addresses to be presented. Speakers and their subjects include:

T. M. Rector, of New York, vice-president of the General Foods Corporation, will speak on "Quality in Fruits and Vegetables"; E. C. Thompson, of New York, director of the laboratories of the Borden Company, will discuss "Quality in Dairy Products."

"Visual Aspects of Quality Control and Quality Research with Beverages and Foods" will be the topic of a paper by D. Foster, E. C. Ziegler and E. H. Scofield, of Joseph E. Seagram and Sons, Inc., of Louisville, Ky. A paper on "Coffee Flavor and Retention vs. Temperature and Type of Container" will be read by L. B. Sjostrom and E. C. Crocker, of A. D. Little, Inc., of Cambridge, Mass., and H. W. Schultz, of Swift and Company, Chicago.

A. L. Winton, of Winton Laboratories, Wilton, Conn., a former associate of Dr. Wiley, will present a paper on "Harvey W. Wiley, the Father of American Food Chemistry." "Quality in Meat and Meat Products" will be the subject of O. G. Hankins, U. S. Department of Agriculture. E. C. Crocker, of A. D. Little, Inc., will describe "Volatility in Food Flavors."

Wiley, who "probably did more than any other individual to raise American food standards to the high plane which they occupy to-day," was from 1883 to 1912 chief chemist of the U. S. Department of Agriculture. He was born in a log cabin in Kent, Jefferson County, Indiana. He died on June 30, 1930.

#### HONORARY DEGREES TO BE CONFERRED BY THE UNIVERSITY OF ALGIERS

By a decree dated June 20, 1944, the Commissioner of National Education of the Provisional Government of the French Republic approved the decision of the board of the University of Algiers to confer the degree of doctor "honoris causa" on a number of scientific men and men of action of Allied and friendly nations. The names of those on whom the degrees will be conferred include:

Serge Bernstein, professor of mathematics in the University of Leningrad.

Brigadier General E. R. Boland, member of the Royal Medical College in London and dean of Guys Hospital Medical School, London.

G. Bourdenke, head surgeon of the Russian Army.

L. Bourgoïn, professor of chemical industry at the Military Academy of Artillery and Engineering, Montreal.

E. D. Churchill, John Homans professor of surgery at the Harvard Medical School.

James Bryant Conant, president of Harvard University. A. V. Hill, Foulerton research professor of physiology of the Royal Society, London.

J. Huphrede, professor at McGill University, Montreal. Alvin Johnson, director of the New School for Social Research, New York.

Peter Kapitza, director of the Institute of Physical Problems of the Academy of Sciences of the U.S.S.R.

Li Ju Jing, president of the National Academy of China and president of the Franco-Chinese University of Peking.

P. H. Long, professor of general medicine, the Johns Hopkins University.

Dean Mackenzie, director of the National Center of Scientific Research, Canada.

Miguel Ozorio de Almeida, professor of physiology, the University of Rio de Janeiro.

Georges Prefontaine, director of the Biological Institute of the University of Montreal.

A. Roubakine, professor of microbiology, Moscow.

#### AWARD TO THE NATIONAL ACADEMY OF SCIENCES

THE following letter has been addressed to Dr. Frank B. Jewett, president of the National Academy of Sciences, by Major General L. H. Campbell, Jr., Chief of Ordnance, War Department.

It is my pleasure as Chief of Ordnance of the Army to tell you on behalf of the Ordnance Department that I am most grateful for the outstanding contributions the National Academy of Sciences has made to Ordnance progress in this war. The degree of that progress is best shown by the success of our fighting forces in all theaters of operations.

To attest the appreciation of the Department for the splendid services of your Academy, I wish to present to the Academy the Ordnance Distinguished Service Award. It is a diploma bearing the traditional seal of the Department and is awarded in recognition of scientific and engineering achievement.

I will be pleased to have one of the officers of my staff make the presentation of the diploma publicly at some date which suits your convenience and best conforms to the schedule of meetings of the Academy.

### SCIENTIFIC NOTES AND NEWS

THE Hosea Ballou Medal for distinguished service was conferred on the occasion of the eighty-eighth commencement exercises of Tufts College on Dr. Arthur B. Lamb, Erving professor of chemistry at Harvard University, in recognition of his work as "one of

America's very great scientists and great teacher of young scientists."

NORTHWESTERN UNIVERSITY at its recent commencement conferred the doctorate of science on Dr. Herman L. Kretschmer, professor of urology at Rush



Medical College, Chicago, president of the American Medical Association.

IN honor of his coming retirement on reaching his seventieth year, Dr. Francis B. Sumner, professor of biology at the University of California, was given on July 29 a surprise party at the home of Dr. H. U. Sverdrup, director of the Scripps Institution of Oceanography at La Jolla. All the members of the Scripps Institution save those away on leave, including staff, students and assistants, attended. Dr. Harry Beal Torrey, professor emeritus of biology at Stanford University, now a practising physician, reviewed Dr. Sumner's distinguished professional career and his own long and intimate friendship with both Dr. and Mrs. Sumner. Another old friend, Dr. Wesley R. Coe, professor emeritus of biology at Yale University, and several of Dr. Sumner's colleagues at the Scripps Institution added warm personal tributes to Dr. Sumner as a friend and scholar. Numerous letters were received from absent colleagues and former students. As a further token of their regard, his friends presented him with a set including barometer, hygrometer and thermometer mounted in a single frame bearing small engraved brass panels memorializing the occasion. A handsome gift was also presented to Mrs. Sumner.

L. L. LONGSDORF, extension editor of Kansas State College, has been elected vice-president of the American Association of Agricultural College Editors.

AT the twenty-first annual meeting of the Long Island Biological Association, held on July 25 at Cold Spring Harbor, L. I., Dr. E. C. MacDowell, resident investigator of the Department of Genetics of the Carnegie Institution of Washington, was elected secretary. Members of the Board of Directors, who were elected to the Class of 1948, are as follows: Professor W. H. Cole, of Rutgers University; Mrs. George S. Franklin, Dr. E. C. MacDowell and William B. Nichols, of Cold Spring Harbor; Roland L. Redmond, of Oyster Bay, and Dr. B. H. Willier, of the Johns Hopkins University.

AT the University of Kansas, the retirement is announced of Frederick E. Kester, since 1909 professor of physics and until 1941 chairman of the department of physics and astronomy, and of Professor Martin E. Rice, who has been associated with the department of physics since 1892.

AT the Ohio State University, Professor Edmund M. Spieker has been appointed head of the department of geology, and Professor Ralph A. Knouff chairman of the department of anatomy.

DR. A. IRVING HALLOWELL has been appointed professor of anthropology at Northwestern University.

DR. LEO T. SAMUELS has resigned as associate professor of physiological chemistry at the University of Minnesota to become head of the department of biochemistry of the School of Medicine at the University of Utah.

DR. DONALD F. HOFFMEISTER, associate in zoology and curatorial assistant in the Museum of Vertebrate Zoology of the University of California at Berkeley, has been appointed assistant professor of zoology at the University of Kansas and assistant curator of modern vertebrates in the Museum of Natural History.

DR. GORDON FERRIE HULL, JR., has been appointed assistant professor of physics at Dartmouth College.

DR. ALTON H. GUSTAFSON, associate professor of biology and academic executive officer of the V-5 Unit at Williams College, has been appointed acting dean of the college and coordinator of the V-12 Unit.

DR. LLOYD D. SEAGER has been appointed professor of pharmacology and toxicology at the Woman's Medical College of Pennsylvania to succeed Dr. Ben King Harned, who has joined the research staff of Lederle Laboratories, Inc.

THE department of physics of the University of California at Los Angeles announces the following changes: Professor S. J. Barnett has retired with the title emeritus. He will continue his work on gyromagnetism at the California Institute of Technology. Professor V. O. Knudsen, dean of the Graduate Division, has returned after nearly three years spent with the National Defense Research Committee. Dr. J. W. Ellis has been promoted to a full professorship of physics and has been appointed chairman of the department. Professor Joseph Kaplan is serving as chief of operations analysis, Second Army Air Force. Assistant Professor A. H. Warner has been promoted by the Army to the rank of colonel, and is serving in England with the Supreme Command, A.E.F. Dr. L. P. Delsasso, Lieutenant Commander, U.S.N.R., has been promoted to an assistant professorship but is serving with the U. S. Navy Radio and Sound Laboratory in San Diego, Calif. To serve in the absence of regular members of the staff, Professor James A. Swindler, head of the department of physics of Westminster College, New Wilmington, Pa., has become an assistant professor. The work in meteorology, heretofore done within the department of physics, has now been taken over by the newly established department of meteorology, of which Professor Jakob Bjerknes is chairman.

EDWARD M. CHACE, since 1914 in charge of the Laboratory of Fruit and Vegetable Chemistry (formerly the Citrus By-Products Laboratory), U. S. Department of Agriculture at Los Angeles, retired on June 30 after forty-two years of government service.



DR. GEORGE S. AVERY, professor of botany and director of the Arboretum of Connecticut College, New London, took up his work as director of the Brooklyn Botanic Garden on July 1. He succeeds Dr. George S. Reed, who has been acting director since the death last August of Dr. C. Stuart Gager. Dr. Gager had been director of the garden since its establishment in 1910.

ALMON G. HOVEY, director of research of Reichhold Chemicals, Inc., of Detroit, has been appointed executive in charge of the new chemicals development section of the Research Laboratories of General Mills.

THE Office of Price Administration has appointed Franklin Gindick, a graduate of the University of California, to be head of the Fruit and Vegetable Branch of its Food Price Division.

DR. G. F. D'ALELIO, director of chemical research of the Pro-phy-lac-tic Brush Company, has been elected a vice-president of the company.

RUTGERS UNIVERSITY has announced the organization of a Division of Acoustical Research in the College of Engineering for the purpose of investigating airborne sounds. The work will be done under contract with the Office of Scientific Research and Development and will be directed by Dr. Carl F. Eyring, professor of physics, Brigham Young University. Other members of the staff are Arthur A. Allen, professor of ornithology, Cornell University; Wayne B. Hales, professor of physics, Brigham Young University; James L. Potter, professor of electrical engineering, Rutgers University; Peter P. Kellogg, assistant professor of ornithology, Cornell University; Obed C. Haycock, associate professor of electrical engineering, University of Utah; and Wm. L. Nastuk, assistant in physiology, and Anthony J. Del Mastro, instructor in civil engineering, both of Rutgers University.

DR. PAUL BRINDLEY, professor of pathology at the School of Medicine at Galveston of the University of Texas, has returned from a hospital tour in Costa Rica, Guatemala, Honduras and Mexico City, where he made special studies in tropical medicine under the auspices of the John and Mary R. Markle Foundation.

DR. GEORGE B. CRESSEY, who has been on leave of absence from Syracuse University, where he has been chairman of the department of geology and geography since 1931, has returned from Asia, where he served as visiting professor in China under the cultural relations program of the Department of State. While in China he also served as a representative of the National Academy of Sciences, and carried the greetings of numerous American scholarly organizations. He was able to visit more than twenty-five university and

research centers in Chungking, Kunming, Kweiyang, Kweilin, Changsha, Foochow, Chengtu, Lanchow and Tihwa. On his way to China last fall he spent a month in India, where he studied university problems. On his return trip he travelled through Soviet Middle Asia and spent some time in Tashkent, Samarkand, Bukhara and Baku. During the past twenty years Professor Cressey has made four trips to Asia, and has travelled more than 100,000 miles in that continent. For six years he taught at the University of Shanghai. Professor Cressey will return to Syracuse University in September. He is lecturing during August at the Summer Session of Columbia University and at the Naval School of Military Government.

DR. GEORGE M. CURTIS, formerly dean and professor of surgery at the Medical School of the University of Oklahoma, gave the Leroy Long Memorial lecture on June 21. He spoke on "The Surgery of the Spleen."

A STAFF member of the British Museum writes that concussion from flying bombs has destroyed much glass in that institution, and that one which exploded in the street did much damage to the bird and animal exhibition galleries.

AN Associated Press dispatch reports that Yale University has received from an anonymous donor a complete set of the official patent specifications for the iron and steel inventions of Sir Henry Bessemer, as well as a complete set of photostats of plans and scale diagrams relating to the patents. They were given in recognition of the "untiring devotion to the high purposes of his vocation and of his outstanding accomplishments as associate dean of the Sheffield Scientific School" of Professor Loomis Havemeyer.

THE residuary estate of the late Mrs. Caroline Bamberger Fuld, estimated to amount to approximately a million dollars, is bequeathed to the Institute for Advanced Study at Princeton, N. J., of which she was one of the founders.

THE American Foundation for Pharmaceutical Education has been presented by a number of drug firms with the sum of \$485,000.

THE Commonwealth Fund has made a grant of \$10,000 to the National Committee for Mental Hygiene to provide fellowships to train psychiatrists for work with children.

A RESEARCH fellowship is open in the Laboratory of Hematology at Michael Reese Hospital, Chicago, under the direction of Dr. Raphael Isaacs. An intensive study of leukemia is being made. Between three thousand and five thousand dollars are available for the fellowship, depending on the qualifications of the individual.

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## DISCUSSION

## THE HISTOLOGICAL CHANGES IN THE PITUITARY CAUSED BY ESTROGEN

LONG-CONTINUED estrogen injections into animals are known to result in enlargement of the pituitary, vascularity, loss of chromophil granules and increased numbers of chromophobe cells showing mitoses, hypertrophy of the Golgi apparatus and mitochondria. It has been stressed repeatedly by Severinghaus<sup>1</sup> that these changes are all cytological manifestations of excessive discharge by the pituitary of secretory products. However, estrogen inhibits pituitary secretion of FSH and growth hormone.

Severinghaus has regarded the cytological changes that are indicative of hyperfunction of the pituitary resulting from estrogen as an unsolved contradiction to the physiological evidence of hypofunction. He writes: "How may these apparent contradictions of cytology and physiology be reconciled? No complete and convincing answer is available, but certain suggestions may be relevant." His suggestions are based on the assumption that the cytological and the physiological evidence are concerned with the same pituitary factor, namely, the gonadotropic.

It seems to me the difficulty in this apparent paradox is that the cytologist is assuming that the hyperfunction, of which he sees microscopic evidence, is of the gonadotropic hormone. It seems that all can be reconciled if one thinks of the possibility that the cytological appearance of hypersecretion may be a matter of secretion of the pituitary factor stimulating the mammary gland, which is produced with such intensity that the pituitary is diverted from producing adequate amounts of gonadotropin and growth hormone, and is stimulated to compensate by excess production of precursor cells.

Those studying pituitary histology have largely overlooked the mammary gland hyperplasia and secretion of milk induced by estrogen. Meites and Turner<sup>2</sup> review their own experiments and others, proving that estrogen induces lactation in virgin animals and increases the lactogen content of the pituitary. Those who have studied induction of lactation by estrogen have usually not studied pituitary histology. In parabiotic rats, the writer<sup>3,4</sup> found excess endogenous estrogen caused enlargement and degranulation of the pituitary, secretion by the mammary gland, regression

of corpora lutea and stunting of body growth. It seems reasonable to suppose that when the pituitary is stimulated by estrogen to lactogen production in excess, a demand is made upon all available precursor cells so that there is inability of the pituitary to form FSH, LH and growth hormone. Furthermore, this may explain the histological appearance of the pituitary in pregnancy. The so-called pregnancy cells are no longer regarded as a specific type of cell, but as degranulated chromophils. Because these cells show hypertrophy of Golgi apparatus and mitochondria and loss of cell granules, Severinghaus<sup>1</sup> interprets these changes as indicative of secretion by the pituitary, and again implies that he means secretion of gonadotropins, as he states that "Physiological experiments have led to a rather general conception that pregnancy inhibits the secretory activity of the anterior lobe. . . . Cytological findings point strongly in an exactly opposite direction." In the light of what has been said, is it not reasonable to regard the cytological changes in the pituitary in pregnancy as due to the high estrogen production by the placenta? Bachner<sup>5</sup> and Severinghaus<sup>1</sup> pointed out similarity between the effects of estrogen on pituitary cytology and the appearance of the pituitary in pregnancy. It seems reasonable to ascribe the histological changes to hypersecretion of the pituitary factor stimulating the mammary gland during the period when the breast is undergoing hyperplasia preliminary to lactation and to secretion of lactogen when the final period of pregnancy is reached.

ISOLDE T. ZECKWER

DEPARTMENT OF PATHOLOGY,  
UNIVERSITY OF PENNSYLVANIA  
MEDICAL SCHOOL

## G. J. ROMANES ON THE EXCITABILITY OF MUSCLE

ALL students of evolutionary theory are familiar with the fundamental contributions of George John Romanes in that field, but it is to be regretted that his physiological studies are not nearly so well known. Inasmuch as the elucidation of the electrical and chemical factors underlying muscular fatigue is a most important objective of research in neuromuscular physiology, Romanes' work along this line should be recalled.

In a letter<sup>1</sup> to Charles Darwin, dated August 13, 1877, Romanes says:

<sup>5</sup> F. Bachner, *Ztschr. f. Geburt. u. Gynäk.*, 106: 87, 1933.

<sup>1</sup> Ethel Romanes, "Life and Letters of George John Romanes," second edition; Longmans, Green, London, 1896, page 64.

<sup>1</sup> A. E. Severinghaus, in "Sex and Internal Secretions" by E. Allen. Second edition, 1939. Williams and Wilkins Company, Baltimore.

<sup>2</sup> J. Meites and C. W. Turner, *Endocrinology*, 30: 711, 719, 726, 1942.

<sup>3</sup> I. T. Zeckwer, *Arch. Path.*, 30: 461, 1940.

<sup>4</sup> I. T. Zeckwer, *Federation Proceedings*, 1: 186, 1942.



I am very glad you have drawn my attention prominently to the localizing function in *Drosera*, as it is very likely I have been too keen in my scent after nerves; and I believe it is chiefly by comparing lines of work that in such novel phenomena truth is to be got at. And this reminds me of an observation which I think ought to be made on some of the excitable plants. It is a fact not generally known, even to professed physiologists, that if you pass a constant current through an excised muscle two or three times successively in the same direction, the responses to make and break become much more feeble than at first, so that unless you begin with a strong current for the first of the series, you have to strengthen it for the third or fourth of the series in order to procure a contraction. But on now reversing the direction of the current, the muscle is tremendously excitable for the first stimulation, less so for the second, and so on. Now this rapidly exhausting effect of passing the current successively in the same direction, and the wonderful effect of reversing it, point, I believe, to something very fundamental in the constitution of muscular tissue. The complementary effects in question are quite as decided in the jelly-fish as in frog's muscle; so I think it would be very interesting to try the experiment on the contractile tissues of plants.

The discovery of the above-described phenomenon is generally credited to Gulaesy, who reported it in 1929.<sup>2</sup> When one considers that Romanes also first observed, in the umbrella of the jelly fish, what is now known as fibrillation, it would seem appropriate to take cognizance of his important physiological research by attaching his name to one of these phenomena. It is therefore suggested that the recovery of excitability of a tissue upon reversal of polarity of a stimulating current be called the "Romanes effect."

H. J. RALSTON

COLLEGE OF DENTISTRY AND  
DEPARTMENT OF MEDICINE,  
UNIVERSITY OF CALIFORNIA

#### THE GENERIC NAME OF THE SAND FLY

In a paper published in *SCIENCE* for May 26, 1944, Dr. Charles T. Brues stated that I overlooked the reason for spelling *Flebotomus* with a "ph" and not with an "f" as I claimed it should be spelled. Rondani<sup>1</sup> in his original description spelled the word *Flebotomus*. Dr. Brues claims that this is an evident typographical error on Rondani's part and as such should be corrected. I can not see where this can be considered a typographical error as Rondani used it many times. Dr. Brues bases his arguments on the fact that the word *Flebotomus* was derived from the Greek words vein (*φλεβός*) and cutting (*γομή*) and the correct Latinized form would be spelled with a "ph" and not "f."

<sup>2</sup> Z. V. Gulaesy, *Arch. f. d. ges. Physiol.*, 223: 407, 1929.

<sup>1</sup> *Mem. Prima. Serv. Dipt. Ital.*, 1840, p. 12.

This then becomes a question for the students of classical languages; furthermore it is the custom of Italians to translate the Greek "ph" as "f." Rondani very often deviated from the standards that are now accepted as proper in Latin and there can be little doubt that the name was printed the way he intended. According to the general understanding of generic names, the name must be used as originally spelled except when there is an absolutely unquestioned typographical error. Since the use of *Flebotomus* by Rondani is not an unquestioned typographical error I believe that Dr. Brues' argument is without foundation and the spelling *Flebotomus* is correct.

WILLIAM F. RAPP, JR.

CHATHAM, N. J.

#### A SURVEY OF FOOD PRICES

PALO ALTO is a university town of about 18,000 population. Some of the residents are engaged in business in San Francisco, some are retired, while others, normally a small proportion of the whole, are employed by industries in Palo Alto and adjacent communities. Otherwise the town may be regarded as a typical university community—the residents engaged in activities that center about Stanford University.

Since 1939 a shopping survey has been made among the retail food stores of Palo Alto, in all cases during the third or fourth week of May. The results may be of more than local significance, for they indicate trends in retail food prices that are probably apparent in other communities.

Year by year the same items were priced. To give a proper weighting to the list the quantities of various foodstuffs required for a liberal diet were used. The cost of such a diet was calculated for one week's maintenance of an adult man engaged in moderate physical activity.

While it is recognized that many different liberal diets could be devised, all would be characterized by being comparatively low in highly processed and refined cereals and comparatively rich in so-called protective foods and high quality protein foods. The particular diet that we have priced contains an abundance of dairy products, fresh fruit and vegetables and high-quality proteins. Differences in regional dietary practices or in seasonal availability of foodstuffs would permit many variations without serious trespass upon the limits of a liberal diet. The particular foods about which these surveys have centered would provide per day approximately 3,180 calories, 137 gm of fat, 318 gm of carbohydrate, 107 gm of protein, 1.36 gm of calcium, 2.04 gm of phosphorus, 20 mg of iron, 15,000 units of vitamin A or its equivalent, 160 mg of ascorbic acid, 370 units of vitamin D,

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1.4 mg of thiamin and 2.7 mg of riboflavin. These values refer to the food as purchased and should be reduced by probably 10 per cent. to reflect the values for food as consumed.

The list of foods, per adult per week, is as follows:

Bread .....	1 lb.	Sw. potatoes..	1 lb.
Oatmeal .....	$\frac{1}{2}$ "	Potatoes .....	3 lbs.
Cornmeal .....	$\frac{1}{2}$ "	Cabbage .....	2 "
Sugar .....	1.2 lbs.	Lettuce .....	$\frac{1}{2}$ lb.
Milk .....	3 $\frac{1}{2}$ qts.	Carrots .....	1 "
Cheese .....	$\frac{1}{2}$ lb.	Beets .....	1 "
Butter .....	$\frac{1}{2}$ "	Canned corn ..	$\frac{1}{2}$ "
Eggs .....	7 (lg. Gr. A)	Oranges .....	2 lbs.
Lard .....	$\frac{1}{2}$ lb.	Apples .....	1 lb.
Side bacon .....	$\frac{1}{2}$ "	Bananas .....	1 "
Beef chuck		Dried prunes..	$\frac{1}{2}$ "
roast .....	2 $\frac{1}{2}$ lbs.	Canned	
Pink salmon ..	1 lb.	peaches .....	$\frac{1}{2}$ "

Five stores were included in the 1939 survey, six in 1940, seven in 1941 and nine in 1942, 1943 and 1944. Three of the stores in the 1939 list and four in the subsequent lists are members of chains. A large co-operative store was included. All small stores were deliberately omitted as well as one or two stores which cater to luxury trade and are recognized as atypical in respect to distribution costs and retail prices.

In the case of canned goods the cheapest brands were priced. It is believed that the nutritive qualities were reasonably comparable. To obtain maximum economies in purchasing, quantity prices (up to 10 pounds) were used whenever feasible as the basis for the calculations (see Table 1).

The increases reported since 1939 are not to be considered as indicative of the extent to which the cost of living has increased. This is because cost-of-living indices include many items other than food, and also

TABLE 1  
COST OF DIET

	1939	1940	1941	1942	1943	1944
Average cost at retail .....	2.28	2.28	2.96	3.59	4.72	4.26
Percentage increase over 1939 .....		0	30	57	107	87

because liberal diets are low in cereal products (which have increased but little) and rich in fresh vegetables, fruits, fish, eggs, dairy products and meat (which have increased considerably). For example, there has been no increase in Palo Alto in the retail price of bread, cornmeal and oatmeal during the six-year period, but very substantial increases in fresh vegetables and meat.

A substantial decrease in price is apparent since the 1943 survey. This is largely due to decreases in the retail price of fresh vegetables (down 23 to 67 per cent.), beef and bacon (down 12 and 28 per cent., respectively).

The point value of the diet has changed but little in the past year: 37 red and 10 blue in 1943; 35 red and 12 blue in 1944. This consideration is of relatively little importance since substitutions (fresh fish, poultry, rabbit, game, meats other than beef) capable of cutting substantially the red point value are quite possible from time to time.

The assistance of Barbara Davey, Charlotte Gibb, Betty Judson and Nancy Smith, in collection and compilation of the data, is gratefully acknowledged.

J. MURRAY LUCK

DEPARTMENT OF CHEMISTRY,  
STANFORD UNIVERSITY

## SCIENTIFIC BOOKS

### NORTH AMERICAN FOSSILS

*Index Fossils of North America.* By HERVEY W. SHIMER and ROBERT R. SHROCK. A Publication of the Technology Press, Massachusetts Institute of Technology. New York: John Wiley and Sons, Inc. \$20.00.

EVER since "North American Index Fossils" went out of print, Shimer has been working on a revision, which now, with Shrock's enthusiastic cooperation, has come out as a new book. It is no mere compilation; its 837 pages and 303 plates are crammed with new information and illustrations. It is a library in itself. Many a course in invertebrate paleontology could be given with this book alone. With it in hand, the instructor will be saved endless time which would otherwise be employed in hunting out illustrations in separate publications.

Best of all, it is up to date, or as nearly so as is

humanly possible in a printed work. Genera and species bear their correct names, vouched for by specialists. Seldom has there been such an example of perfect cooperation, an obvious tribute to the authors.

Full credit for assistance is given to all collaborators, even to the present writer, who did little more than to say yes or no, as problems came up. Certain sections are credited entirely to the specialists who contributed original manuscripts. Thus we find, as primarily responsible for their sections, Joseph A. Cushman, Loyd G. Henbest and W. Storrs Cole, Foraminifera; Lewis M. Cline, Blastoidea; Raymond C. Moore and Lowell R. Laudon, Crinoidea; Edwin B. Branson and Maurice G. Mehl, conodonts; G. Arthur Cooper, Brachiopoda; J. Brookes Knight and Josiah Bridge, Paleozoic Gastropoda; Frank M. Carpenter, Insecta; Raymond E. Peck, Charophyta; and J. Harlan Johnson, calcareous algae. In this list of impor-



tant collaborators the phrase "assisted by the authors" occurs. This remark applies to the whole book. Never before have we had such short, concise, yet ample taxonomic descriptions. Paleontologists (and others) would do well to "read, mark, learn, and inwardly digest." The bibliographic references are full and well chosen.

Shimer and Shrock have managed to combine the strictly scientific with the fully utilitarian. Paleontologists will thank them for the time they have spent in determining genotypes, time saved for the individual worker. Stratigraphers will thank them for the excellent illustrations and lucid descriptions. Every geologist and paleontologist must have access to a copy, and to those whose livelihood depends upon stratigraphic knowledge it is indispensable.

I shall not use the trite expression that it is a "labor of love" on the part of the authors. It is a labor of service. They get nothing from it except the thanks of those whom they have so well served and the realization that a long arduous task is finally done, and I think all will agree with me, extremely well done.

The book has, of course, the inevitable minor faults. A few letters and figure numbers got misplaced, and some authors are free, who should be in brackets. But the whole work gives evidence of the most painstaking care; and of careful selection of those fossils most likely to prove useful. Some workers will deprecate the fact that almost twice as many pages are devoted to the crinoids as to the Foraminifera, for the latter are thousands of times more abundant than the former, and infinitely more useful. But there are good manuals for the identification of "forams," whereas the determination of a crinoid until now has been a matter of lengthy search. Moore and Laudon's diagrams are most helpful in bringing the crinoids within the grasp of the non-specialist. Cooper's chapter, 89 pages, goes a long way toward restoring the brachiopods to their once honored position as highly important index fossils. All in all, this book gives to the general practitioner much that has been the property of the specialist. Accurate identifica-

tions can be made far more easily than heretofore. It is the greatest contribution to advancement in our branch of science since the first edition of the Eastman-Zittel Text-book of Paleontology.

PERCY E. RAYMOND  
MUSEUM OF COMPARATIVE ZOOLOGY

### VEGETABLE FATS AND OILS

*Vegetable Fats and Oils (Their Chemistry, Production and Utilization for Edible, Medicinal and Technical Purposes)*. By GEORGE S. JAMIESON. Second edition. 508 pp. New York City: Reinhold Publishing Company. 1943. \$6.75.

IN writing the second edition of his book, Dr. Jamieson has again performed a valuable service to all those engaged in the study and use of vegetable fats and oils. Although there has been no extensive alteration of the arrangement of subject-matter, Dr. Jamieson has corrected several misstatements and many awkward phrases that crept into the earlier edition. The ideas are now clearly expressed.

Several devices have been used to bring the book up to date. Whole paragraphs or pages of new material have been added, especially in the description of fats and oils analyzed only since the publication of the first edition and in the chapter on methods. At other points, new literature references were added to the lists furnished previously with many sections throughout the book or, as on page 16, a sentence refers the reader to a symposium and another book in the field.

The reviewer had hoped that, in bringing out his second edition, Dr. Jamieson would attempt a more critical appraisal of the existing literature. With his intimate acquaintance of so many varied approaches to the subject and his acknowledged prestige, the author was in a unique position for that kind of much needed writing. The book does serve to introduce the newcomer to the field and to provide the specialist with a well-organized body of useful information on the source, the general and detailed characteristics and composition, methods of analysis and the uses of the vegetable oils and their component fatty acids.

HERBERT E. LONGENECKER

## AMERICAN MEN OF SCIENCE

### SCIENTIFIC MEN RECEIVING STARS IN THE SEVENTH EDITION

FOR the seventh edition of the Biographical Directory of "American Men of Science," there have been selected, by the same objective methods as have been used in previous editions, two hundred and fifty-five names of those not included in earlier selections who are regarded by their colleagues as among the leading

scientific workers in the United States. This method has been fully described in the fourth and earlier editions of the work. Table 1 gives the number of those now living that have appeared in each of the seven editions of the directory.

The names, given below, of those who received stars



TABLE 1  
STARS IN AMERICAN MEN OF SCIENCE  
Included in Seventh Edition

	First Edition	Second Edition	Third Edition	Fourth Edition	Fifth Edition	Sixth Edition	Seventh Edition	Total
Anatomists .....	10	4	5	3	5	5	7	39
Anthropologists .....	3	2	6	2	5	5	5	28
Astronomers .....	10	3	15	11	13	13	13	78
Botanists .....	37	16	21	23	25	25	25	172
Chemists .....	28	26	42	40	41	43	44	264
Geologists .....	24	16	24	21	23	24	27	160
Mathematicians .....	31	13	26	18	20	20	21	149
Pathologists .....	14	11	21	14	14	15	15	104
Physicists .....	46	20	43	34	36	37	37	262
Physiologists .....	9	8	16	9	9	10	11	72
Psychologists .....	19	7	15	9	11	12	13	86
Zoologists .....	58	20	30	30	35	36	37	246
Totals .....	289	155	264	214	237	245	255	1659

in the seventh edition are grouped under twelve sciences. This is the same grouping as has been used in previous editions.

#### *Anatomists*

William Bloom, University of Chicago  
Elizabeth Crosby, University of Michigan  
Chester H. Heuser, Carnegie Institution, Baltimore  
Joseph C. Hinsey, Cornell University Medical College  
J. Parsons Schaeffer, Jefferson Medical College  
Gordon H. Scott, University of Southern California  
William F. Windle, Med. Sch., Northwestern University

#### *Anthropologists*

John M. Cooper, Catholic University of America  
Carl E. Guthe, University of Michigan  
Alfred I. Hallowell, University of Pennsylvania  
Wilton M. Krogman, University of Chicago  
Harry L. Shapiro, American Museum of Natural History

#### *Astronomers*

S. Chandrasekhar, Yerkes Obs., University of Chicago  
Wallace J. Eckert, U. S. Naval Observatory  
Robert R. McMath, McMath-Hulbert Observatory  
Nicholas U. Mayall, Lick Obs., Univ. of California  
Rudolph Minkowski, Mt. Wilson Obs., Carnegie Inst.  
William W. Morgan, Yerkes Obs., University of Chicago  
Svein Rosseland, Princeton University  
Martin Schwarzschild, Columbia University  
Lyman Spitzer, Yale University  
P. Swings, Yerkes Obs., University of Chicago  
A. N. Vyssotsky, University of Virginia  
Fred L. Whipple, Harvard Observatory  
Olin C. Wilson, Mt. Wilson Obs., Carnegie Institution

#### *Botanists*

Ernest G. Anderson, Calif. Institute of Technology  
John M. Arthur, Boyce Thompson Institute  
Eugene C. Auchter, U. S. Department of Agriculture  
George S. Avery, Jr., Connecticut College  
P. R. Burkholder, Yale University  
William H. Chandler, University of California  
Jens Clausen, Stanford University

John N. Couch, University of North Carolina  
Charles Drechsler, U. S. Department of Agriculture  
Adrianee Foster, University of California  
Robert F. Griggs, George Washington University  
John S. Karling, Columbia University  
George W. Keitt, University of Wisconsin  
David H. Linder, Harvard University  
Walter F. Loehwing, Iowa State University  
Barbara McClintock, Carnegie Inst., Cold Spring Harbor  
Paul C. Mangelsdorf, Harvard University  
George W. Martin, State University of Iowa  
Walter Muenscher, Cornell University  
Lee O. Overholts, Pennsylvania State College  
Albert J. Riker, University of Wisconsin  
George L. Stebbins, Jr., Univ. of Calif., Berkeley  
Kenneth Thimann, Harvard University  
Philip R. White, Rockefeller Institute, Princeton  
Frederick A. Wolf, Duke University

#### *Chemists*

John Aston, Pennsylvania State College  
Paul D. Bartlett, Harvard University  
Henry E. Bent, University of Missouri  
Gerald E. K. Branch, Univ. of Calif. at Berkeley  
Laurenee O. Brockway, University of Michigan  
Wallace R. Brode, Ohio State University  
George Calingaert, Ethyl Gasoline Corporation  
Ralph Connor, University of Pennsylvania  
Arthur C. Cope, Columbia University  
Moses L. Crossley, Calco Chemical Company  
Peter Debye, Cornell University  
Malcolm Dole, Northwestern University  
John T. Edsall, Harvard Medical School  
Robert C. Elderfield, Columbia University  
Kasimir Fajans, University of Michigan  
Merrell R. Fenske, Pennsylvania State College  
Paul J. Flory, Esso Laboratory  
Karl A. Folkers, Merck & Company, Inc.  
Frank T. Gucker, Jr., Northwestern University  
Henry B. Hass, Purdue University  
Ernst A. Hauser, Mass. Institute of Technology  
Kenneth C. D. Hickman, Distillation Products Inc.  
Maurice L. Huggins, Eastman Kodak Company  
Ernest H. Huntress, Mass. Institute of Technology  
Warren C. Johnson, University of Chicago



Martin Kilpatrick, University of Pennsylvania  
 Charles G. King, University of Pittsburgh  
 Phillip Leighton, Stanford University  
 Bernard Lewis, U. S. Bureau of Mines  
 Samuel M. McElvain, University of Wisconsin  
 Randolph T. Major, Merck & Company, Inc.  
 Herman F. Mark, Polytechnic Institute of Brooklyn  
 Joseph E. Mayer, Columbia University  
 Carl R. Noller, Stanford University  
 John L. Oncley, Mass. Institute of Technology  
 Kenneth S. Pitzer, Univ. of California at Berkeley  
 Gerhard K. Rollefson, Univ. of California at Berkeley  
 G. Frederick Smith, University of Illinois  
 Lee I. Smith, University of Minnesota  
 Wendell M. Stanley, Rockefeller Institute, Princeton  
 Charles A. Thomas, Monsanto Chemical Company  
 Hubert B. Vickery, Connecticut Agr. Exp. Station  
 Everett S. Wallis, Princeton University  
 E. Bright Wilson, Jr., Harvard University

#### Geologists

Charles A. Anderson, University of California  
 Marland P. Billings, Harvard University  
 Josiah Bridge, U. S. Geological Survey  
 Wilbur S. Burbank, U. S. Geological Survey  
 Gustav A. Cooper, U. S. National Museum  
 Carey Croneis, University of Chicago  
 Everette L. DeGolyer, Office Petrol. Coord. Nat. Defense  
 Richard F. Flint, Yale University  
 David T. Griggs, U. S. Geological Survey  
 John W. Gruner, University of Minnesota  
 Wm. O. Hotchkiss, Rensselaer Polytechnic Institute  
 Earl Ingerson, Carnegie Institution, Washington  
 G. Marshall Kay, Columbia University  
 Paul F. Kerr, Columbia University  
 Philip B. King, U. S. Geological Survey  
 William C. Krumbein, University of Chicago  
 Arville I. Levorsen, Tulsa, Oklahoma  
 John B. Mertie, Jr., U. S. Geological Survey  
 Walter H. Newhouse, Mass. Institute of Technology  
 Reno Sales, Anaconda Copper Mining Company  
 John F. Schairer, Carnegie Institution, Washington  
 S. James Shand, Columbia University  
 Max N. Short, University of Arizona  
 George G. Simpson, American Museum of Natural History  
 George Tunnell, Carnegie Institution, Washington  
 Charles E. Weaver, University of Washington  
 Howel Williams, University of California, Berkeley

#### Mathematicians

Emil Artin, Indiana University  
 Claude Chevalley, Princeton University  
 Joseph L. Doob, University of Illinois  
 Kurt Godel, Institute for Advanced Study, Princeton  
 Jacques Hadamard, Columbia University  
 Gustav A. Hedlund, University of Virginia  
 Witold Hurewicz, University of North Carolina  
 Nathan Jacobson, University of North Carolina  
 Derrick H. Lehmer, Univ. of California, Berkeley  
 Saunders MacLane, Harvard University

Karl Menger, Notre Dame University  
 Richard von Mises, Harvard University  
 Deane Montgomery, Smith College  
 Otto Neugebauer, Brown University  
 George Polya, Stanford University  
 John B. Rosser, Cornell University  
 Carl L. Siegel, Inst. for Advanced Study, Princeton  
 Paul A. Smith, Columbia University  
 Andre Weil, Lehigh University  
 Samuel S. Wilks, Princeton University  
 Antoni Zygmund, Mt. Holyoke College

#### Pathologists

Rene J. Dubos, Harvard University  
 Rolla E. Dyer, U. S. Public Health Service  
 Thomas Francis, Jr., University of Michigan  
 Harry Goldblatt, Western Reserve University  
 Frank L. Horsfall, Rockefeller Institute, New York  
 Robert F. Loeb, Columbia University  
 Balduin Lucke, University of Pennsylvania  
 James H. Means, Harvard University  
 J. Howard Mueller, Harvard University  
 Peter Olitsky, Rockefeller Institute, New York  
 Edwards A. Park, Johns Hopkins University  
 John R. Paul, Yale University  
 Oswald H. Robertson, University of Chicago  
 James S. Simmons, U. S. Army  
 Shields Warren, Harvard University

#### Physicists

Luis W. Alvarez, Mass. Institute of Technology  
 Katharine B. Blodgett, General Electric Company  
 Leon Brillouin, Brown University  
 H. Richard Crane, University of Michigan  
 Robley D. Evans, Mass. Institute of Technology  
 Enrico Fermi, Columbia University  
 Wendell H. Furry, Harvard University  
 W. W. Hansen, Stanford University  
 Gaylord P. Harnwell, University of Pennsylvania  
 Raymond G. Herb, University of Wisconsin  
 Frederick V. Hunt, Harvard University  
 Elmer Hutchisson, University of Pittsburgh  
 Francis A. Jenkins, University of California  
 Mervin J. Kelly, Bell Telephone Laboratories  
 Donald W. Kerst, University of Illinois  
 Paul Kirkpatrick, Stanford University  
 Paul E. Klopsteg, Central Scientific Company  
 Karl Lark-Horovitz, Purdue University  
 Edwin M. McMillan, University of California  
 Henry Margenau, Yale University  
 A. C. G. Mitchell, Indiana University  
 Seth H. Neddermeyer, Calif. Institute of Technology  
 Alfred O. Nier, University of Minnesota  
 Wayne P. Nottingham, Mass. Institute of Technology  
 Brian O'Brien, University of Rochester  
 Wolfgang F. Pauli, Inst. for Adv. Study, Princeton  
 Louis N. Ridenour, University of Pennsylvania  
 Bruno Rossi, Cornell University  
 Ralph A. Sawyer, University of Michigan  
 Frederick Seitz, Jr., University of Pennsylvania



William Shockley, Bell Telephone Laboratories  
 Hertha Sponer, Duke University  
 Julius Stratton, Mass. Institute of Technology  
 John D. Strong, California Institute of Technology  
 George E. Uhlenbeck, University of Michigan  
 John A. Wheeler, Princeton University  
 William H. Zachariasen, University of Chicago

#### Physiologists

David B. Dill, Harvard University  
 Carl A. Dragstedt, Northwestern University  
 Conrad Elvehjem, University of Wisconsin  
 William F. Hamilton, University of Georgia  
 Paul J. Hanzlik, Stanford University  
 Rafael Lorente de N , Rockefeller Inst., New York  
 Franklin C. McLean, University of Chicago  
 Henry A. Mattill, Iowa State University  
 Carl F. Schmidt, University of Pennsylvania  
 Arthur L. Tatum, University of Wisconsin  
 Maurice B. Visscher, University of Minnesota

#### Psychologists

Charles W. Bray, Princeton University  
 Elmer Culler, University of Rochester  
 Clarence H. Graham, Brown University  
 Joy P. Guilford, University of Southern California  
 Edwin R. Guthrie, University of Washington  
 Ernest R. Hilgard, Stanford University  
 Carlyle F. Jacobsen, Washington University  
 Donald G. Marquis, Yale University  
 Gardner Murphy, College of the City of New York  
 Burrhus F. Skinner, University of Minnesota  
 Stanley S. Stevens, Harvard University  
 Robert C. Tryon, University of California, Berkeley  
 Morris S. Viteles, University of Pennsylvania

#### Zoologists

James E. Ackert, Kansas State College  
 Howard B. Adelmann, Cornell University  
 Lester G. Barth, Columbia University  
 George W. Beadle, Stanford University  
 H. W. Beams, State University of Iowa  
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 S. C. Brooks, University of California, Berkeley  
 J. William Buchanan, Northwestern University  
 Elmer G. Butler, Princeton University  
 Lee R. Dice, University of Michigan

Emmett R. Dunn, Haverford College  
 Boris Ephrussi, Johns Hopkins University  
 G. F. Ferris, Stanford University  
 Herbert Friedmann, U. S. National Museum  
 Myron Gordon, New York Aquarium  
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 Clarence H. Kennedy, Ohio State University  
 Harold Kirby, Jr., Univ. of California, Berkeley  
 R. R. Kudo, University of Illinois  
 S. F. Light, Univ. of California, Berkeley  
 Norman E. McIndoo, U. S. Department of Agriculture  
 Ernst Mayr, American Museum of Natural History  
 Peter Okkelberg, University of Michigan  
 Thomas Park, University of Chicago  
 Arthur W. Pollister, Columbia University  
 James A. G. Rehn, Acad. of Natural Sciences, Philadelphia  
 Karl P. Schmidt, Chicago Museum of Natural History  
 Francis O. Schmitt, Mass. Institute of Technology  
 Oscar E. Schott , Amherst College  
 Tracy M. Sonneborn, Indiana University  
 C. L. Turner, Northwestern University  
 Albert Tyler, California Institute of Technology  
 William C. Young, Yale University

Much discussion has appeared in the columns of *SCIENCE* in regard to the desirability of the starring system and in regard to possible changes from the present method of selection.

It was planned to revise the system of starring for the seventh edition. A distinguished committee was appointed by the American Association for the Advancement of Science to study and to look into methods that might be used in order that a fair distribution of stars among the different sciences be made. Special attention should be given to those working in related and cross-over sciences, which under the present system do not necessarily have full consideration. Owing to the war, however, the committee of the Association was not able to function in time for the publication of the seventh edition, but it is hoped that a completely revised plan beginning with the eighth edition will be evolved.

JACQUES CATTELL,  
*Editor*

## SPECIAL ARTICLES

### ANTIBIOTINS<sup>1</sup>

In accordance with our interest in antibiotic compounds we have explored further the antibiotic activity of certain derivatives of biotin and other compounds which are structurally related to biotin. The

<sup>1</sup> The authors wish to express their appreciation to Mrs. Glenn Ellis, Miss Carol Tompkins and Miss Kate Redmond for technical assistance in the bioassays.

antibiotin activity of desthiobiotin for some microorganisms has already been reported.<sup>2,3</sup>

We thought it also might be timely to record the microbiological activity of compounds which did not possess antibiotic activity but which stimulated the

<sup>2</sup> K. Dittmer, D. B. Melville and V. du Vigneaud, *SCIENCE*, 99: 203, 1944.

<sup>3</sup> V. G. Lilly and L. H. Leonian, *SCIENCE*, 99: 205, 1944.

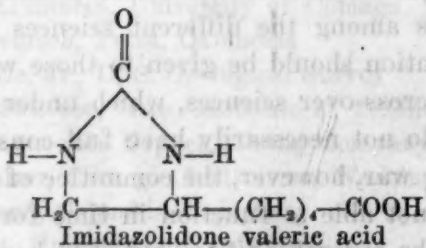
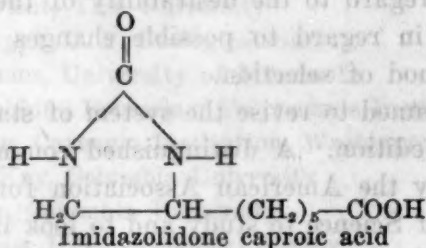


growth of either or both *S. cerevisiae* and *L. casei* and to record the ability of these compounds to combine with avidin.

One of the most potent antibiotin compounds we have encountered in our experiments is the sulfone of biotin.<sup>4</sup> Biotin sulfone inhibited the growth of *L. casei*, *L. arabinosus* and *Staph. aureus*. For *S. cerevisiae*, however, biotin sulfone was found to act as a growth stimulant in place of biotin in the medium, although its activity was considerably less than that of biotin.<sup>5</sup>

The antibiotin action of biotin sulfone was thoroughly investigated with *L. casei*. For this organism when incubated for 66 hours, the molar inhibition ratio<sup>6</sup> was calculated to be 280, i.e., 280 molecules of sulfone inhibited the effect of one molecule of biotin. The inhibition of growth exerted by biotin sulfone was completely reversed by the addition of more biotin. It has been observed that if the incubation time in the growth test is increased the inhibition ratio also increases.

Two analogues of desthiobiotin have been synthesized, namely, 4-(imidazolidone-2)-caproic acid and 4-(imidazolidone-2)-valeric acid.<sup>7</sup> The structures of these compounds are as follows:



Imidazolidone caproic acid differs from desthiobiotin only by lacking the methyl group attached to the imidazolidone ring, whereas the imidazolidone valeric acid, in addition to the lack of the ring methyl, has one less methylene group in the side chain.

Imidazolidone caproic acid was found to be an antibiotin for both *L. casei* and *S. cerevisiae*. This inhibitory effect on both of these organisms was reversed by the addition of more biotin. The molar inhibition ratio of imidazolidone caproic acid for *L. casei* was 126,000, and for yeast 760,000.

In contrast to the antibiotin activity of imidazolidone caproic acid, imidazolidone valeric acid stimulated the growth of yeast. Imidazolidone valeric acid

in amounts sufficient to produce maximum yeast growth (equivalent to 0.005 microgram biotin) did not stimulate the growth of *L. casei* in a biotin-free medium. Furthermore, large amounts of imidazolidone valeric acid did not inhibit the growth of *L. casei* produced by small amounts of biotin. These tests would indicate that even though the yeast-growth-promoting activity of imidazolidone valeric acid is of a very low order, it is not due to contamination with biotin.

All the compounds tested which have a urea ring and a carboxylic acid side chain of 5 or 6 carbon atoms are able to combine with avidin, whereas all compounds which lack the cyclic urea structure are unable to do so. This is further evidence of the importance of the urea structure for the interaction of biotin with avidin.<sup>8</sup> The side chain also seems essential, for it was found that ethylene urea and 4-(imidazolidone-2)-carboxylic acid did not interact with avidin. Just how much the carboxylic acid side chain can be shortened without the loss of the ability to combine with avidin remains to be determined.

It has been possible to demonstrate that biotin sulfone, imidazolidone caproic acid and imidazolidone valeric acid can displace biotin from the avidin-biotin complex. Any one of these compounds when added to yeast or *L. casei* cultures in the presence of avidin-bound biotin is capable of displacing some of the biotin which then becomes available for the growth of the organisms.

<sup>4</sup> K. Hofmann, D. B. Melville and V. du Vigneaud, *Jour. Biol. Chem.*, 141: 207, 1941.

<sup>5</sup> K. Dittmer, V. du Vigneaud, P. György and C. S. Rose, *Arch. Biochem.*, 4: 229, 1944.

<sup>6</sup> The molar inhibition ratio is a figure representing the antibiotin activity of the compound. It is expressed as the number of molecules of an antibiotin required to inhibit one molecule of biotin, and is determined experimentally as the amount of an antibiotin which is able to reduce the growth obtained with 0.0002 microgram biotin to a level equivalent to that obtained with 0.0001 microgram biotin. Thus the smaller the molar inhibition figure, the greater the antibiotin activity of a given compound.

<sup>7</sup> The imidazolidone caproic acid was synthesized from pimelic acid. Pimelic acid was converted to the half ester acid chloride. The latter was treated with diazomethane and subsequently with HCl to obtain ethyl-(8-chloro-7-keto)-octanoate. The 8-amino-7-keto-octanoic acid was obtained from the latter with potassium phthalimide followed by hydrolysis. With KCNO, the amino ketone was then converted to the imidazolone which upon reduction yielded the desired compound. Imidazolidone caproic acid melted at 145° and gave the following analysis:

$C_9H_{15}O_3N_2$	Calculated	C 53.98	H 8.06	N 14.00
200.2	Found	53.80	8.06	14.06

The imidazolidone valeric acid was prepared in a similar manner from adipic acid. This compound melted at 170° and gave the following analysis:

$C_7H_{11}O_3N_2$	Calculated	C 51.60	H 7.58	N 15.05
186.2	Found	51.66	7.61	15.10

The details of the syntheses will be reported elsewhere.

<sup>8</sup> V. du Vigneaud, K. Dittmer, K. Hofmann and D. B. Melville, *Proc. Soc. Exp. Biol. and Med.*, 50: 374, 1942.



The biological activities of the various derivatives of biotin and the simpler analogues are tabulated in Table 1. The growth-promoting activities are ex-

TABLE 1

THE GROWTH-PROMOTING AND ANTIBIOTIN ACTIVITIES OF COMPOUNDS STRUCTURALLY RELATED TO BIOTIN AND THEIR INTERACTION WITH AVIDIN

Compound	Growth-promoting activity		Antibiotin activity*		Combination with avidin
	Yeast	<i>L. casei</i>	Yeast	<i>L. casei</i>	
	per cent.	per cent.			
Biotin	100	100	none	none	Yes
Biotin sulfone	0.1	0	none	280	Yes
Dethiobiotin	100	0	none	9,100	Yes
Biotin diaminocarboxylic acid	10	< 0.01	none	none	No
Dethiobiotin diaminocarboxylic acid	10	0	none	none	No
Imidazolidone valeric acid	0.0017	0	none	none	Yes
Imidazolidone caproic acid	0	0	760,000	126,000	Yes

\* Antibiotin activity is expressed as the molar inhibition ratio.<sup>6</sup>

pressed as per cent. activity of biotin. If the compound has antibiotin activity its molar inhibition ratio is given.

KARL DITTMER

VINCENT DU VIGNEAUD

DEPARTMENT OF BIOCHEMISTRY,  
CORNELL UNIVERSITY MEDICAL COLLEGE,  
NEW YORK

#### GERMINATION OF LETTUCE SEED AT HIGH TEMPERATURE STIMULATED BY THIOUREA

THOMPSON and Kosar<sup>1</sup> have shown that the germination of dormant lettuce seed can be stimulated by treating the seed with a dilute solution of thiourea. Investigations by the senior author demonstrate further that thiourea-treated lettuce seed can be germinated at a much higher temperature than untreated seed.

Ten different strains of lettuce seed were selected for these studies. A portion of each of the 10 lots of seed was soaked in a 0.5 per cent. solution of thiourea in Petri dishes in darkness in a constant temperature chamber at 18° C. for 7 hours. After soaking, the seed was washed in tap water to remove the thiourea solution from the surface of the seed. The treated seed was then spread out thinly on absorbent paper in diffused light and thoroughly dried. After drying the seed was placed in brown paper envelopes and stored at room temperature for 10 days when

<sup>1</sup> Ross C. Thompson and Wm. F. Kosar, *Plant Physiol.*, 14: 567-573, 1939.

each lot was tested for germination on wet filter paper in Petri dishes in a germinator at 33°-35° C. Treated and untreated samples of each of the 10 strains were tested for germination in quintuplicate lots of 25 seed each with the results presented in Table 1.

TABLE 1

SUMMARY OF DATA ON THE INFLUENCE OF THIOUREA ON THE GERMINATION OF 10 STRAINS OF LETTUCE SEED AT HIGH TEMPERATURE, 33°-35° C. FOR 5 DAYS

Strain numbers	Thiourea-treated seed						Untreated seed					
	replications						replications					
	1	2	3	4	5	Total	1	2	3	4	5	Total
1541-1	22	21	19	24	21	107	0	0	0	0	0	0
1562-4	23	23	23	22	24	115	0	0	0	0	0	0
1562-8	23	22	25	24	24	118	0	0	0	0	0	0
1568-2	25	25	25	24	25	124	0	0	0	0	0	0
1592-12	24	24	25	25	24	122	0	0	0	0	0	0
1620-7	15	20	18	18	20	91	0	0	0	0	1	1
1624-4	25	25	25	25	25	125	0	6	0	1	1	8
1624-9	25	25	25	24	24	123	0	0	0	1	0	1
1640-4	16	23	17	21	20	97	0	0	1	0	0	1
1664-1	15	11	16	16	10	68	0	0	0	0	0	0
Total												
Per cent. germinated												
	1090						11					
	87.2						0.88					

The germination temperature used (33°-35° C.) is much too high for the ordinary germination of lettuce seed as is shown by the 0.88 per cent. average for all 50 lots of untreated seed. However, the 50 lots of thiourea treated seed gave an average germination of 87.2 per cent. The strains of seed responded differently to the treatment. Four of the 10 lots, numbered 1568-2, 1592-12, 1624-4 and 1624-9, gave almost 100 per cent. germination when treated as described.

Three strains, numbers 1620-7, 1640-4 and 1664-1, gave the poorest response to the treatment with 72.8, 77.6 and 54.4 per cent. germination, respectively. All but a few weak embryos appeared to be normal.

Numerous other variations of the treatment, including temperature, length of time of treatment and exposure to light while soaking, have been studied. The procedure outlined above has been found to be near the optimum for the strains so far tested.

Many lots of lettuce seed treated as described have been planted in soil; germination was rapid and normal plants resulted. Although none of the tests in soil have been carried out at the extremely high temperature of 33°-35° C., the maximum temperature frequently reached 30° during the warmest part of the day.

There is reason to believe that the thiourea treatment may have a practical application for assuring satisfactory germination where it is necessary to plant when the soil temperature is too high for germination of most commercial lettuce seed.

ROSS C. THOMPSON

BUREAU OF PLANT INDUSTRY,  
U. S. DEPARTMENT OF AGRICULTURE,  
BELTSVILLE, MD.



# THE EXCRETION OF PENICILLIN IN THE SPINAL FLUID IN MENINGITIS<sup>1</sup>

RAMMELKAMP and Keefer<sup>2</sup> found that penicillin injected intravenously is not excreted into the spinal fluid. Similar observations have not been conducted on patients with meningitis. The present study was undertaken to determine whether significant amounts of penicillin are excreted into the subarachnoid space in patients with meningitis following intravenous or intramuscular administration.

## MATERIAL AND METHODS

Eight patients with meningitis were chosen for this study. In 6 of these, meningococci were recovered from the spinal fluid. None of the subjects had received any form of specific therapy prior to this study. Penicillin,<sup>3</sup> in a dilution of 5,000 Oxford units per cc of isotonic saline solution, was administered intramuscularly to 2 subjects and intravenously to 6 subjects, taking one minute for each injection. Three of the subjects received 20,000 units, and the other 5 were given 40,000 units. The diagnostic lumbar puncture was performed 60 to 140 minutes later and the spinal fluid thus obtained was assayed for its penicillin content, using a modification of Foster's turbidometric method.<sup>4</sup> On the basis of their estimated potency, the samples of spinal fluid were diluted in sterile water to give a solution containing approximately 0.1 Oxford unit per ml. Varying amounts of the dilutions were then added to tubes containing 10 ml of nutrient broth, inoculated with *Staphylococcus aureus*, and incubated 16 hours at 37° C. Turbidometric measurements of the amount of growth were made with a photoelectric colorimeter. The potency of the samples was calculated from a standard curve run at the same time as the test samples.

As controls, spinal fluid was obtained from 3 of these subjects ten days after discontinuing penicillin and was assayed for its antibacterial effect.

## RESULTS

In all 8 subjects, penicillin was excreted in the spinal fluid (Table 1). Subject 1, who received 20,000 units of penicillin intravenously, showed a concentration of 0.35 unit of penicillin per cc of spinal fluid 60 minutes after injection. One hundred and twenty minutes

after a similar injection, 0.03 unit of penicillin per cc of spinal fluid was found in Subject 2. When 20,000 units were administered intramuscularly to Subject 3, 0.05 unit per cc of spinal fluid was found 120 minutes later.

TABLE 1  
SHOWING THE AMOUNT OF PENICILLIN IN THE SPINAL FLUID AFTER INTRAVENOUS AND INTRAMUSCULAR ADMINISTRATION

Subject	Amount of penicillin administered (units)	Route of administration	Interval after administration (minutes)	Amount of penicillin in spinal fluid (units/cc)
1	20,000	Intravenous	60	0.35
2	20,000	Intravenous	120	0.03
3	20,000	Intramuscular	120	0.05
4	40,000	Intravenous	90	0.32
5	40,000	Intravenous	125	0.26
6	40,000	Intravenous	125	0.09
7	40,000	Intravenous	75	0.04
			135	0.12
8	40,000	Intramuscular	140	0.26

Ninety minutes after the intravenous injection of 40,000 units of penicillin, 0.32 unit per cc of spinal fluid was found in Subject 4. One hundred and twenty-five minutes after the same dose, 0.26 unit per cc of spinal fluid was detected in Subject 5, and 0.09 unit per cc in Subject 6. In Subject 7, who likewise received 40,000 units intravenously, the spinal fluid showed 0.04 unit per cc in 75 minutes and 0.12 unit per cc in 135 minutes. Subject 8 was given 40,000 units intramuscularly, and 140 minutes later 0.26 unit per cc was found in the spinal fluid.

It is evident from these data that the amounts of penicillin excreted in the spinal fluid in meningitis vary with different subjects. Nevertheless, the concentrations found in these studies, particularly after the administration of 40,000 units, are sufficient to produce a marked bacteriostatic effect.

None of the control samples of spinal fluid showed any antibacterial effect.

## COMMENT

Rammelkamp and Keefer<sup>5</sup> found that penicillin in concentrations of 0.019 to 0.156 unit per cc of serum produced maximum bactericidal effects against the *Streptococcus hemolyticus*, and at least 0.156 unit per cc was necessary for maximum bacteriostatic action against *Staphylococcus aureus*. Further, they observed that the antistreptococcal action of whole blood containing 0.007 unit of penicillin per cc is much greater than that of whole blood containing 5.1 mg of sulfadiazine per 100 cc of blood. When these data are correlated with our findings, the concentrations of penicillin in the spinal fluid of our subjects may be regarded as adequate for the control of men-

<sup>5</sup> C. H. Rammelkamp and C. S. Keefer, *Jour. Clin. Invest.*, 22: 425, 1943.

<sup>1</sup> This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the U. S. Navy. The opinions and views set forth are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

<sup>2</sup> C. H. Rammelkamp and C. S. Keefer, *Am. Jour. Med. Sci.*, 205: 342, 1943.

<sup>3</sup> The sodium salt of penicillin was used in this study.

<sup>4</sup> J. W. Foster, *Jour. Biol. Chem.*, 144: 285, 1942.



ingest infections produced by susceptible organisms, without the need of supplementary intrathecal therapy. Inasmuch as the concentration of penicillin at comparable periods varies with different subjects, it would appear, however, that larger and/or more frequent doses than have generally been administered intravenously or intramuscularly may be required to obtain the maximum bacteriostatic effects and to preclude the development of penicillin resistance. Whether this method of therapy will be as effective or produce clinical responses as promptly as that observed when combined with intrathecal administration (Rosenberg and Arling)<sup>6,7</sup> must await clinical trial. Further studies along this line are indicated.

#### SUMMARY AND CONCLUSIONS

(1) Penicillin was administered in doses of 20,000–40,000 Oxford units intravenously or intramuscularly to 8 subjects with meningitis. Sixty to 140 minutes later penicillin was found in the spinal fluid in concentrations of 0.03 to 0.35 unit per cc.

(2) These data suggest that penicillin administered intravenously or intramuscularly in adequate dosages may be effective in the treatment of meningitis without supplementary intrathecal therapy.

DAVID H. ROSENBERG,

Lieutenant Commander (MC), U.S.N.R.

J. C. SYLVESTER

GREAT LAKES, ILL.

## SCIENTIFIC APPARATUS AND LABORATORY METHODS

### THE GOLDEN HAMSTER (*CRICETUS AURATUS*) AS A TEST ANIMAL FOR THE DIAGNOSIS OF LEPTOSPIROSIS

THE investigation of leptospirosis due to infection with *Leptospira canicola* has been seriously handicapped by the lack of a readily susceptible laboratory host, whereas numerous species are known to be susceptible to *L. icterohaemorrhagiae*.<sup>1</sup>

Meyer, Stewart-Anderson and Eddie<sup>2</sup> chose young guinea pigs weighing 50–100 grams for their studies on canine leptospirosis. They state that the spirochetes associated with dog infections are of a low pathogenicity for rodents and that in young guinea pigs weight loss was a better criterion of infection than a febrile reaction. However, three to five passages were required to produce a definite weight loss and an occasional fatal infection.

The purpose of this paper is to report the use of hamsters for the isolation of both *L. canicola* and *L. icterohaemorrhagiae* from naturally infected dogs, and further, to report the first instance in which the classical strain, *L. icterohaemorrhagiae*, has been isolated from the dog in the United States.

#### SUSCEPTIBILITY OF HAMSTERS TO VIRULENT STRAINS OF LEPTOSPIRA

Our early attempts to isolate *Leptospira* from the blood and urine of dogs following the injection of suitable material into young guinea pigs were as unsatisfactory as those reported by Meyer and his co-workers.<sup>2</sup> The experimental data on the use of

hamsters reported by Morton<sup>1</sup> and the suggestion of Dr. Carl L. Larson, of the U. S. Public Health Service, led to the choice of hamsters three to four weeks old and weighing 25 to 30 grams for experimental work.

*Leptospira canicola* was first isolated in young hamsters after injection of the urine of an acutely ill dog whose serum on the day the urine sample was collected had a positive agglutination titer for *L. canicola* in a dilution of 1–2,000 and a cross titer for *L. icterohaemorrhagiae* in a 1–10 dilution. The urine specimen was obtained by catheter on February 15, 1943, and centrifuged in an angle centrifuge at 3,500 RPM for one-half hour. The sediment was suspended in sterile saline solution and injected intraperitoneally into four young hamsters and four young guinea pigs. Within 9 to 10 days the hamsters died of leptospirosis. *L. canicola* was demonstrated by dark-field examination of portions of the kidney and liver, in sections stained by a silver staining method and cultured in Fletcher's broth. The injected guinea pigs remained normal in appearance.

This strain of *L. canicola* isolated from dog urine injected in young hamsters has been labelled Strain "A" and the confirmation of its pathogenicity for hamsters has been reported by Larson<sup>3</sup> in his paper on "Experimental Leptospirosis in Hamsters." On the second passage of this strain in hamsters marked icterus appeared three to four days after injection of the animals, death following within 5 to 6 days after inoculation.

Later the owner of the dog from which Strain "A" was isolated became seriously ill with canicola fever, the diagnosis being based on the serologic findings and the demonstration of leptospira in his urine by dark-

<sup>3</sup> C. L. Larson, Public Health Reports, 59: 522, 1944.

<sup>6</sup> D. H. Rosenberg and P. A. Arling, *U. S. Naval Med. Bull.* In press.

<sup>7</sup> *Ibid.*: *Jour. Am. Med. Assoc.* In press.

<sup>1</sup> H. E. Morton, *Proc. Soc. Exp. Biol. and Med.*, 49: 566, 1942.

<sup>2</sup> K. F. Meyer, B. Stewart-Anderson and B. Eddie, *Jour. Am. Vet. Med. Assn.*, 95: 710, 1939.



field examination. At this time no hamsters were available and urine specimens prepared as described above failed to infect young guinea pigs.

*L. canicola* Strain "B" was also isolated after the intraperitoneal injection of young hamsters with urine sediment from a dog ill with leptospirosis. This dog of the Boxer type apparently became ill on June 15, 1943. The owner, who became ill and was hospitalized on July 25th, admitted having removed soiled newspapers from the dog's quarters on July 4th. The medical officer in charge of the patient reported that her serum developed an agglutination titer of 1-1,000 for *L. canicola* and a cross agglutination titer of 1-10 for *L. icterohaemorrhagiae*.

On August 10th serum obtained from the dog gave a positive agglutination reaction for *L. canicola* in a dilution of 1-1,000 and a cross agglutination for *L. icterohaemorrhagiae* in a dilution of 1-10. At the same time a urine specimen was obtained by catheterizing the dog. The resuspended sediment prepared as previously described was injected into four young hamsters and four young guinea pigs. On August 22 one of the hamsters died and from its kidneys and liver *L. canicola* was cultured in Fletcher's broth and leptospira demonstrated on tissue section.

#### ISOLATION OF *L. ICTEROHAEMORRHAGIAE* FROM A DOG

On May 26, 1943, a Boston terrier was brought to the dispensary presenting symptoms of leptospirosis. A sample of venous blood was obtained and injected intraperitoneally into two young hamsters which died 6 and 7 days after injection. (From this time attempts to infect guinea pigs was abandoned because of our inability to establish an infection, whereas infections were regularly produced in the hamster.)

Leptospira were observed by the dark-field examination of fresh kidney and liver material, in stained sections, and were cultured in Fletcher's broth.

On May 8th a urine specimen, prepared as previously described, was obtained from this dog and injected into four hamsters, three of which died within 2 to 3 days from bacterial infection. The fourth hamster died of leptospirosis eight days after injection. Marked icterus was evident at the time of death. Leptospira were observed by dark-field examination, in tissue sections, and cultured in Fletcher's broth. Typing of the recovered organism from the blood and urine proved it to be *L. icterohaemorrhagiae*.

This dog had a history of having caught rats in a chicken house on the owner's property. The symptoms manifested in this animal were quite mild in comparison with those in the previously mentioned two dogs ill with *L. canicola* infection. This is the first isolation of *L. icterohaemorrhagiae* from a dog in the United States, previous diagnoses of infection with

this species of leptospira having been based on serologic findings.

Differential diagnosis of *L. canicola* and *L. icterohaemorrhagiae* infections may be achieved by injecting material from the suspect into both young guinea pigs and young hamsters, since only the hamster will succumb to infection with *L. canicola* while *L. icterohaemorrhagiae* infections terminate fatally in both species.

#### SUMMARY

There is evidence that the golden hamster (*Cricetus auratus*) is the animal of choice for the isolation of leptospirae, especially of the *Leptospira canicola* type since young guinea pigs and mice are resistant to infection and rats are entirely refractory. Both the classical strain, *L. icterohaemorrhagiae* and *L. canicola* on isolation have been found to produce a fatal infection in hamsters.

The present report deals with the isolation of *L. canicola* in two instances by the injection intraperitoneally into hamsters of urine obtained from dogs ill with suspected leptospirosis. Each of the dogs was apparently the source of infection for a human case of *Canicola leptospirosis*.

The classical strain *L. icterohaemorrhagiae* was isolated from the dog for the first time in the United States. In this instance the organism was isolated by injecting both whole blood and urine from the patient intraperitoneally into young hamsters.

The injection into hamsters of suitable material from patients infected with *L. canicola* and *L. icterohaemorrhagiae* is followed by a fatal leptospirosis in the test animal.

RAYMOND RANDALL,

Colonel, Veterinary Corps

HAROLD K. COOPER,

Captain, Veterinary Corps

ARMY VETERINARY SCHOOL,

MEDICAL DEPARTMENT PROFESSIONAL

SERVICE SCHOOLS,

ARMY MEDICAL CENTER,

WASHINGTON, D. C.

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